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ILLINOIS
COAL MINING INVESTIGATIONS
COOPERATIVE AGREEMENT

State Geological Survey
Engineering Experiment Station University of Illinois
U. S. Bureau of Mines

BULLETIN 3
Chemical Study
OF
Illinois Coals



BY
S. W. PARR

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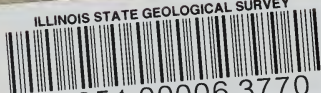
STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS
URBANA
1916

The Forty-seventh General Assembly of the State of Illinois, with a view of conserving the lives of the mine workers and the mineral resources of the State, authorized an investigation of the coal resources and mining practices of Illinois by the Department of Mining Engineering of the University of Illinois and the State Geological Survey in cooperation with the United States Bureau of Mines. A cooperative agreement was approved by the Secretary of the Interior and by representatives of the State of Illinois.

The direction of this investigation is now vested in the Director of the United States Bureau of Mines, the Director of the State Geological Survey, and the Director of the Engineering Experiment Station, University of Illinois, who jointly determine the methods to be employed in the conduct of the work and exercise general editorial supervision over the publication of the results, but each party to the agreement directs the work of its agents in carrying on the investigation thus mutually agreed on.

The reports of the investigation are issued in the form of bulletins, either by the State Geological Survey, the Engineering Experiment Station, University of Illinois, or the United States Bureau of Mines. For copies of the bulletins issued by the State and for information about the work, address Coal Mining Investigations, University of Illinois, Urbana, Ill. For bulletins issued by the United States Bureau of Mines, address Director, United States Bureau of Mines, Washington, D. C.

ILLINOIS STATE GEOLOGICAL SURVEY



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CHEMICAL STUDY OF ILLINOIS COALS

By S. W. Parr

INTRODUCTION

GENERAL STATEMENT

This report on Illinois coals was preceded by a study of sampling and analytical methods conducted by the Illinois Coal Mining Investigations under a cooperative agreement between the State Geological Survey, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines.

The analytical results as presented in the tables should prove serviceable to both consumer and producer. Some of the tables were published in Extract from Bulletin 23, and with additions, again in Bulletin 29 which deals with the purchase and sale of Illinois coals on specification. The "unit-coal" factors especially have so thoroughly demonstrated their practical value that they have been continued as an important feature of the main table of the present report. A supplemental table has also been prepared illustrating the use which may be made of these unit values.

SCOPE OF REPORT

In the fifteen years which have intervened since the first study was made of the chemical composition and properties of the coals of the State, notable advancement has been made in methods of procedure in connection with such work. This result has naturally followed our increased knowledge and better understanding of the properties of this complex substance, but especially has it been caused by the marked changes which have occurred in the methods of purchasing coal, especially on the part of large consumers, whose contracts are based on specifications as to quality. This method has led to a careful scrutiny of all processes yielding factors which enter into the final settlement. Small errors in large consignments may result in serious injustice to one or the other of the parties involved. These studies, therefore, have been especially directed to sampling, the conservation of moisture, and the determination of ash and of heat values.

The practical sampling and analysis of coal involves a number of complex problems and is beset with many difficulties. To this all will

agree who have come in actual contact with such work. That positive improvements in methods and greater accuracy have resulted is evident, but much remains to be done. Some of these difficulties are especially pronounced in coals of the Illinois type with a high content of moisture and sulphur, and an irregular but very positive contamination by calcium carbonate. Doubtless the procuring of a representative sample is the most fundamental and important of all the processes employed, as it is also the most difficult to accomplish in a thoroughly satisfactory manner. The present studies have furnished an unusual opportunity for studying sampling methods, and it is believed that all the attending data have an enhanced value by reason of the accuracy and representative character of the samples obtained.

While in this work, therefore, advantage has been taken of the opportunity for studying sampling methods, there has been much attention given also to ash determinations and the effect of certain abnormal and irregular constituents which affect especially the accuracy of ash values. The ashing of coals having a high percentage both of sulphur and of calcium carbonate may yield results which vary widely, depending upon the amount of calcium sulphate formed in the process. The distribution and amount, therefore, of calcium carbonate are matters of no little importance. This topic has led directly also to a study of the amount of sulphate normally present in Illinois coal, and the interesting fact has been developed in this connection that in the finely ground laboratory sample, especially one having a relatively high percentage of moisture, there occurs a rather active generation of sulphate which has a bearing both upon the ash values and also upon the accompanying heat factors. Correction methods to meet these conditions have been worked out very carefully.

ACKNOWLEDGMENTS

For the chemical analysis, credit is due especially to J. M. Lindgren for his work and supervision, the results of which are embodied in the analytical data. He has been ably assisted by F. H. Whittum, S. C. Taylor, J. F. Kohout, L. T. Fairhall, and Carl W. J. Sievert. A. C. Fieldner of the U. S. Bureau of Mines kindly analyzed sets of duplicate samples used as checks on sampling and analytical methods.

Direct supervision of the mine sampling was vested in the State Geological Survey, F. W. DeWolf, Director, and F. H. Kay, Assistant State Geologist. The sampling was done by three field parties, including the men whose names follow: J. M. Webb of the U. S. Bureau of Mines, and M. L. Nebel, C. W. Smith, H. L. Stafford, J. E. McDonald, and S. T. Wallage, all of the Department of Mining Engineering, University of Illinois.

STUDY OF METHODS OF FIELD SAMPLING

GENERAL PURPOSE

Preliminary to an extended study of the coals of the State, carried on in cooperation with the United States Bureau of Mines and involving the taking of many samples at the working faces of the seams, it was deemed advisable to examine with some care the reliability of the sampling methods employed and to determine, if possible, the degree of accuracy of the final laboratory portion as representing the gross sample from which it was taken. The discussion is not concerned with the relation of different samples to each other or to a coal bed as a whole.

BUREAU OF MINES' STANDARD METHOD

The first method considered was substantially that of the United States Bureau of Mines as given in Technical Paper No. 1. The substance of the directions as there outlined is given as follows:

The collector should smooth and clean the floor and spread the sampling cloth on it close to the face of the coal. Then he should make a perpendicular cut 2 inches deep and 6 inches wide (or 3 inches deep and 4 inches wide in the softer coals) from the roof to the floor down the middle of the foot-wide cut previously made in the coal face. He should be careful to make this cut uniform in width and depth and should chip off enough coal to make a sample weighing at least 6 pounds for each foot of the thickness of the bed; so that the sample collected on the blanket from a 6-foot bed will weigh not less than 36 pounds. Inexperienced collectors should weigh their samples (by spring balance or otherwise) as a check on the accuracy of their work.

As soon as the cutting of the sample has been completed, if the Bureau of Mines outfit is available, the finer portions of the sample should be put through the $\frac{1}{2}$ -inch or $\frac{3}{8}$ -inch screen and the lumps should be broken in the mortar until all the sample passes through the screen. The sample should then be thoroughly mixed by two men grasping the opposite corners of the blanket and rolling it diagonally by raising one corner at a time. When the larger pieces of coal are evenly distributed throughout the mass, the sheet should be laid on the floor and the top of the pile flattened with a clean dry shovel, trowel, or board. The sample is then quartered and two opposite quarters are discarded and brushed off. The remainder is mixed as before, and if the sample is still too bulky for convenient handling it is again quartered down. The material finally remaining is spread into a circular mass about 2 inches deep on the sheet, and the sampling scoop is used to fill the sample can compactly with portions from opposite quarters. The entire operation described above from the cutting of the sample to the sealing of the can should be done in the mine, so as not to expose the coal to the outside atmosphere.

A series of tests carried out in 1908-9, especially for the purpose of determining the representative character of the sample thus produced, is given in outline as follows: two samples were taken by quartering separately the first divisions of the gross sample, and comparison was

made by reference to the ash content of each based on the dry coal. It should be said further that the conditions under which these samples were studied were the most favorable possible. The samples were taken at the mines and were afterwards analyzed in the laboratory by the same persons, thus eliminating those variables which are incident to different samplers and different laboratories. The ash values as obtained from opposite quarters furnish the best index as to the accuracy of the method employed; hence, these values are assembled in Table 1.

TABLE 1.—*Results of tests to determine accuracy of mine-sampling methods by reference to dry-ash values in opposite quarters; series 1908-09*
(Bureau of Mines' standard method of sampling)

Table No.	Lab. No.	County	Duplicate ash (dry-coal basis)		Difference
			Quarter "A"	Quarter "B"	
1	1567	Williamson	11.84	12.17	.33
2	1761	Sangamon	12.48	12.85	.37
3	1773	do	11.71	11.80	.09
4	1796	Knox	7.99	8.39	.40
5	1839	Green	12.43	12.38	.05
6	1846	Edgar	11.42	11.00	.42
7	1870	Christian	9.97	10.67	.70
8	2776	Henry	12.53	12.13	.40
9	2786	Macoupin	10.21	10.10	.11
Average variation					.32

The results in Table No. 1 are on the whole fairly satisfactory; however, occasional discrepancies are shown, which, if due to the method of sampling, should be eliminated. Especially was it desirable to determine whether these variations would be better or worse in the hands of a number of collecting crews such as would be involved in the new work. In order to test this point, the three crews of two men each when first sent into the field were given the instructions as above indicated for sampling, and were required to forward two samples from each lot of coal cut down from the face. These were taken by following separately the opposite pairs of quarters of the first division, and taking duplicate samples in each case of the last division as shown in figure 1. Two pairs of samples of approximately 3 pounds each resulted and were sealed in the regular cans in the usual manner. One pair was forwarded to the University of Illinois at Urbana, and one to the Bureau of Mines at Pittsburgh. As a means of comparison, the results for ash only are given and referred to the dry coal, as shown in Table 2.

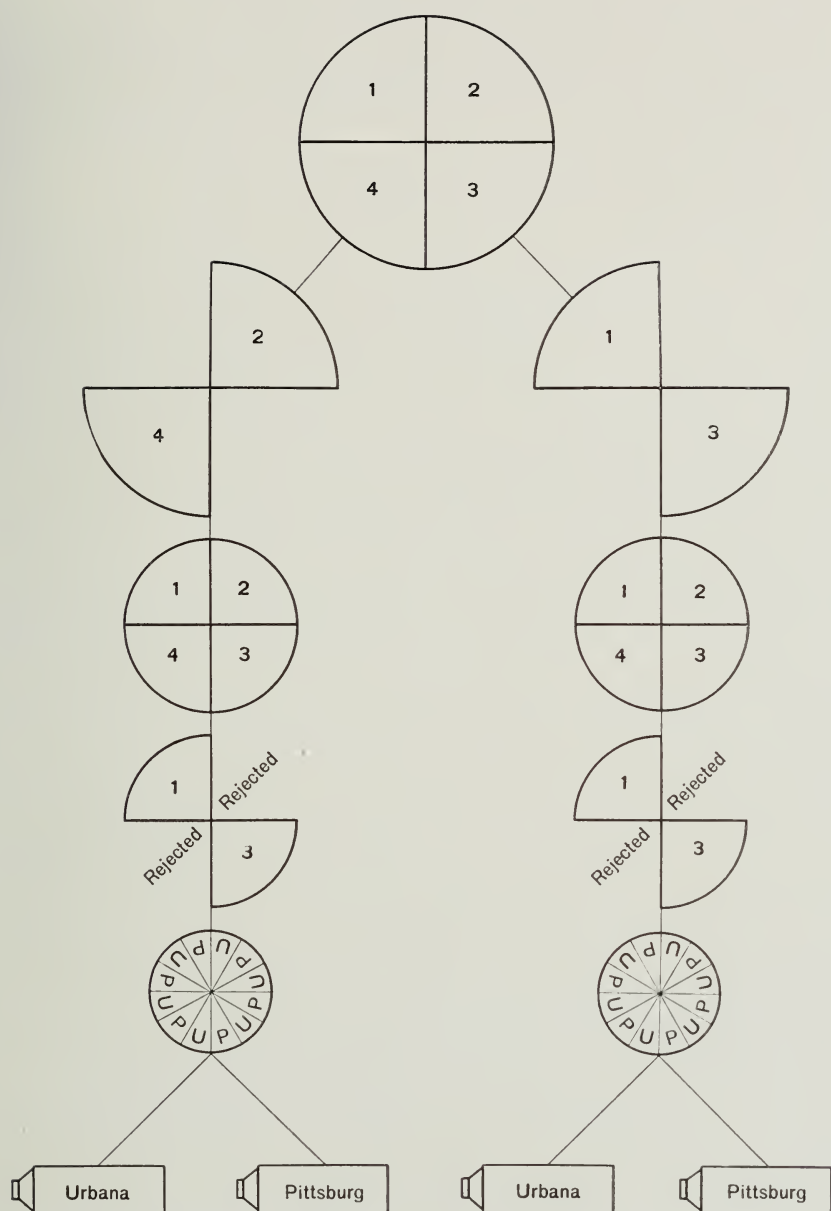


FIG. 1.—Diagram to illustrate the method of subdividing gross sample.

TABLE 2.—Results of tests in two laboratories to determine accuracy of mine-sampling methods by reference to dry-ash values in opposite pairs of quarters; series of 1912^a
(Bureau of Mines' standard method of sampling)

Table No.	Co-op. No.	Illinois State Geological Survey					U. S. Bureau of Mines				Percentage values of one laboratory in excess of values of other		
		Lab No.	Ash			CO ₂	Lab No.	Ash		Average	I. S. G. S.		U. S. B. M.
			Percentage	Difference	Average			Percentage	Difference				
1	54	4756	10.55			0.26	13585F	10.06F			.....		+0.08
2	54	4757	10.09	0.46	10.32	0.15	13578	10.75	0.69	10.40			
3	54	4758	9.83			0.25	13579	9.77			.....		.....
4	54	4759	10.09	0.26	9.96	0.25	13586F	10.16F	0.39	9.96			
5	54	4760	10.82			0.25	13580	11.90			.....		+1.09
6	54	4761	11.00	0.18	10.91	0.32	13587F	12.11F	0.21	12.00			
7	54	4764	12.67			0.37	13581	13.66			.....		
8	54	4765	13.30	0.63	12.98	0.06	13588F	13.08F	0.58	13.37			+0.39
9	54	4766	12.47			0.39	13582	12.94			.....		
10	54	4767	12.83	0.36	12.65	0.38	13589F	13.12F	0.18	13.03			+0.38
11	54	4768	12.08			0.70	13583	12.36			.....		
12	54	4769	11.98	0.10	12.03	0.31	13590F	12.83F	0.47	12.59			+0.56
13	91	4738	10.44			0.55	13573F	10.21F			+1.57		.....
14	91	4745	12.94	2.50	11.69	0.72	13569	10.03	0.18	10.12			
15	91	4739	12.74			0.55	13571F	12.23			.....		
16	91	4742	10.56	2.18	11.65	0.52	13567	12.75	0.52	12.49			+0.84
17	91	4740	13.18			0.96	13572F	11.65F			.....		
18	91	4741	12.30	0.88	12.74	0.90	13568	11.52	0.13	11.58			+1.16

19	92	4699	11.36	0.30	11.51	0.63	13471	11.45	0.04	11.47	+0.04	.....
20	92	4704	11.66	0.30	11.51	0.81	13469	11.49				
21	92	4700	13.82			1.23	13468	11.41				+0.43
22	92	4703	13.47	0.35	13.64	1.26	13467	13.73	0.68	14.07	.....	
23	92	4701	12.79			1.29	13472	12.95				.....
24	92	4702	13.52	0.73	13.15	1.15	13470	13.20	0.25	13.07	+0.08	
25	93	4668	10.23			0.63	13443	10.63				+0.08
26	93	4670	10.05	0.18	10.14	0.52	13436	9.81	0.82	10.22	.....	
27	93	4669	9.40			0.49	13444	9.44				.....
28	93	4671	9.54	0.14	9.47	0.62	13437	9.34	0.10	9.39	+0.08	
29	93	4672	9.95			0.77	13448	10.20				+1.02
30	93	4674	8.40	1.55	9.17	0.63	13441	10.19	0.00	10.19	.....	
31	93	4673	10.40			0.91	13446	10.03				.....
32	93	4676	10.04	0.36	10.22	0.86	13439	10.22	0.19	10.12	+0.10	
33	93	4675	8.96			1.11	13447	10.26				+0.46
34	93	4679	8.72	0.24	8.84	0.46	13440	8.35	1.91	9.30	.....	
35	93	4677	10.50			1.11	13445	9.88				.....
36	93	4678	10.15	0.35	10.31	1.08	13438	9.73	0.15	9.80	+0.51	
37	94	4710	11.29			0.52	13493	10.94				.....
38	94	4711	11.27	0.02	11.28	0.52	13486	11.11	0.17	11.02	+0.26	
39	94	4712	10.46			0.47	13494	10.05				.....
40	94	4713	10.15	0.31	10.30	0.89	13487	10.39	0.34	10.22	+0.08	
41	94	4714	11.56			0.70	13485	10.68				.....
42	94	4717	11.03	0.53	11.29	0.65	13492	10.60	0.08	10.64	+0.65	

TABLE 2.—*Results of tests in two laboratories to determine accuracy of mine-sampling methods by reference to dry-ash values in opposite pairs of quarters; series of 1912^a—Concluded.*
(Bureau of Mines' standard method of sampling)

Table No.	Co-op. No.	Illinois State Geological Survey						U. S. Bureau of Mines				Percentage values of one laboratory in excess of values of other		
		Lab. No.	Ash			CO ₂	Lab. No.	Ash		Average	T. S. G. S.	U. S. G. S.	U. S. B. M.	
			Percentage	Difference	Average			Percentage	Difference					
43	94	4715	11.76			0.88	13491	11.21						
44	94	4716	12.47	0.71	12.11	0.96	13484	11.51	0.30	11.36	+0.75		.....	
45	94	4721	10.33			0.46	13496	9.87						
46	94	4724	10.18	0.25	10.25	0.44	13489	9.88	0.01	9.87	+0.38		.....	
47	94	4722	11.00			0.54	13488	10.59						
48	94	4723	10.95	0.05	10.97	0.38	13495	11.20	0.61	10.89	+0.08		.....	
49	95	4705	8.57			0.42	13452	9.02						
50	95	4706	9.34	0.77	8.95	0.84	13450	8.91	0.11	8.96	.....		+0.01	
51	95	4707	11.44			1.02	13451	11.47						
52	95	4708	10.56	0.88	11.00	0.95	13453	11.36	0.11	11.41	.....		+0.41	
53	97	4727	12.81			0.80	13550	13.04						
54	97	4735	12.64	0.17	12.72	0.83	13554	13.08	0.04	13.06	.....		+0.34	
55	97	4728	11.34			0.74	13553	11.27						
56	97	4734	10.75	0.59	11.04	0.64	13549	10.58	0.69	10.92	+0.12		.....	
57	97	4736	12.00			0.53	13548	11.18						
58	97	4737	11.79	0.21	11.89	0.62	13552	11.51	0.33	11.34	+0.55		.....	

^aDuplicate sets of samples from opposite quarters were analyzed by the U. S. Bureau of Mines and the Illinois State Geological Survey.

These results were for the most part satisfactory, but occasional differences occurred which called for elimination if possible. In the attempt to account for these variations, the first factor considered was the amount of calcium carbonate present. It is well known that the presence of this constituent may be a seriously disturbing factor. For this reason the amount of carbon dioxide for each sample is included in the table. Ordinarily the presence of calcite does not introduce serious variations when the amount present as CaCO_3 is less than about 2 per cent or approximately 1 per cent of CO_2 . A few of the results exceed this amount, as, for example, in some of the duplicates under cooperative numbers 92 and 93. It will be noted that some of the more pronounced variations are found here, though the greatest discrepancies, as in table numbers 13 to 18 inclusive, occur in samples with relatively low CO_2 . However, studies for controlling variations in ash determinations due to the presence of calcium carbonate are taken up later as a special topic for investigation. The results are given in full elsewhere in this bulletin and need not be considered at this point.

The variations in duplicate values from a single laboratory may involve, of course, any differences which may arise from the specific methods employed in handling the samples. As between the values of two laboratories comparison should be made between the averages of the duplicate values obtained by each set of workers (Table 2). In such a comparison we might expect some of the variations to be neutralized or modified.

Whereas the results of each laboratory are fairly consistent, it is difficult to account for occasional irregularities. The same general statement is true when the results from the two laboratories are compared. Since one of the most likely sources of variation is to be found in the sampling, the methods employed for that part of the work have received extended study both in connection with the field collections and especially also with reference to the manipulation of the shipped sample after its arrival at the laboratory.

GRINDER AND RIFFLE METHOD NEW APPARATUS

The two features in the process of procuring the mine sample which were deemed most likely to introduce variations were the method of reducing the gross sample as to size of particles and the method of reducing the mass to a working sample or aliquot of the whole. It is of prime importance that any procedure to be carried on in the mine under the ordinary working conditions must be rapid and not excessively tedious; otherwise the personal equation will become accen-

tuated and this part of the work, which in many respects is the most vital of the entire routine, is likely to be slighted. An attempt was made, therefore, to improve on the Bureau of Mines' method of quartering and crushing the gross sample to finer sizes, and at the same time to remove so far as possible the personal element in carrying out the process.

Two pieces of apparatus were devised to meet the conditions indicated. As a substitute for the tamper for crushing the coal, a portable mill was constructed (fig. 2) having a weight well within the limits of the old tamping kit and having a grinding capacity which would cut down the time usually required for this part of the work. The body of the grinder is cast aluminum and the weight of the grinder complete

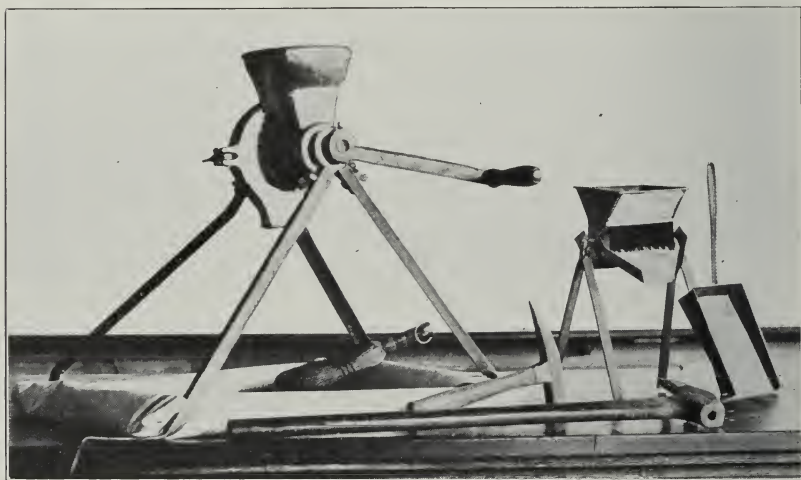


FIG. 2.—Improved sampling outfit.

is not over 18 pounds. It reduces the coal to about 8 mesh, or one-fourth inch at a rate of 40 or 50 pounds in half an hour.

The other feature of the outfit was the riffle. This is shown in the right-hand part of figure 2, and further details are shown in figure 3. This is substantially the riffle described in Bulletin 9 of the Ohio State Geological Survey, the chief difference being that the riffle openings are one-half inch wide instead of five-eighths inch. The entire mass passing the grinder is thoroughly mixed by rolling in the canvas and is put through the riffle and thus reduced to halves. One-half is again riffled and reduced till a portion is obtained which will fill the shipping can. This is then sealed in the usual manner and forwarded at once to the laboratory.

The time consumed in securing a sample depends on many factors besides the time used in reducing the coal to fine size. The sampler is often delayed in entering the mine, and once underground, if the mine is large, as much time is required in moving from one location to another as in securing the samples.

An ordinary gross sample of 40 pounds representing a 6-foot coal can be put through the grinder in 25 to 30 minutes, and the riffing can easily be accomplished in 10 minutes. Besides the saving in labor the coal particles are uniformly reduced to buckwheat size, and the

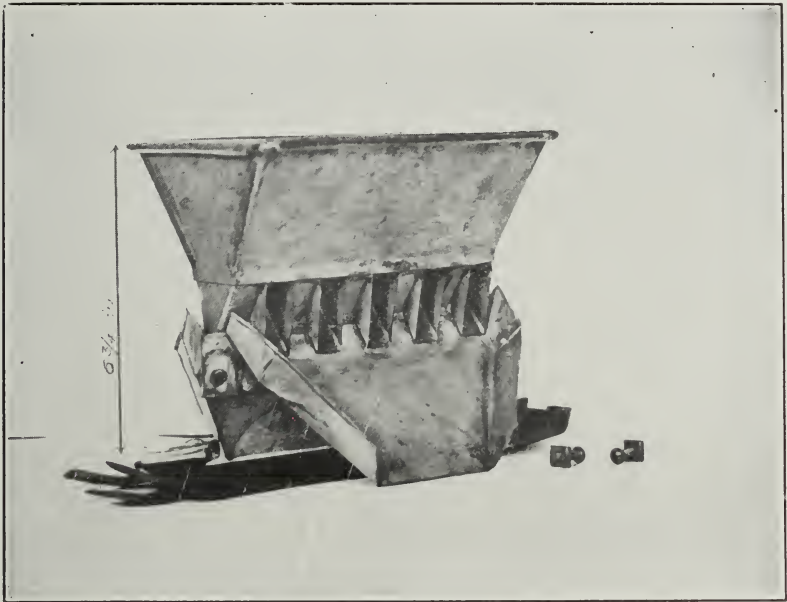


FIG. 3.—Improved riffle.

results would seem to favor the grinder rather than the tamper for this purpose. The actual time consumed is about the same in both methods.

COMPARISON OF RESULTS FROM DIFFERENT LABORATORIES

In testing out the degree of uniformity which might be obtained by use of these devices, the final sample was taken in duplicate, one-half being forwarded to Urbana, and the other to Pittsburgh.

A comparison of ash values is given in Table 3. Here again the values for the calcium carbonate are included as affording a possible explanation, in extreme variations, for differences due to laboratory

methods employed rather than to an unevenness in the parts of the sample. Without exception the high variations are accompanied by CO_2 values of .47 per cent or higher, though not all high-calcite values are accompanied by a wide ash variation. As will be seen later the presence of CaCO_3 accompanied by FeS_2 is conducive to variable results even in the hands of the same operator. Occasionally also the plus and minus errors will neutralize each other and it may happen that two laboratories may agree on a high-calcite coal and again the same coal even in duplicate determinations by the same analyst will give widely varying results, unless special methods are adopted.

COMPARISON OF RESULTS FROM THE SAME LABORATORY

One further method of testing the procedure was tried which brought the ash determinations of the two duplicate samples under the same analytical conditions, thus eliminating such variables as would naturally result from determinations made in separate laboratories. As a check upon the method and also upon the men who were taking the samples, directions were given whereby each crew occasionally forwarded to the laboratory at Urbana samples in duplicate resulting from riffing separately the halves of the gross sample.

All these special duplicate samples are assembled in Table 4.

TABLE 3.—*Results of tests in two laboratories to determine accuracy of mine-sampling methods by reference to dry-ash values in the two final subdivisions of the sample*
(Grinder and riffle method)

Table No.	Co-op. No.	Lab. No.		Percentage of ash		Difference	CO ₂ (dry coal)
		I. S. G. S.	U. S. B. M.	I. S. G. S.	U. S. B. M.		
1	8	5348	14585F	7.62	7.62	.00	1.17
2	8	5349	14584F	7.58	7.46	.12	.59
3	8	5350	14586F	11.49	11.88	.39	2.91
4	15	5286	14545	5.77	5.90	.13	.21
5	15	5287	14547	7.03	7.19	.16	.08
6	15	5288	14546	4.27	4.26	.01	.08
7	19	5338	14608F	10.69	10.59	.10	.47
8	19	5339	14606	13.41	14.50	1.09	1.73
9	19	5340	14607F	8.61	8.67	.06	1.73
10	19	5364	14610F	11.40	11.14	.26	.43
11	19	5365	14611F	13.92	14.55	.63	.91
12	31	5283	14554F	14.73	14.73	.00	2.00
13	31	5284	14555F	12.32	11.94	.38	1.57
14	31	5285	14556F	10.97	11.98	1.01	1.06
15	31	5296	14559F	14.96	14.09	.87	2.02
16	31	5298	14557F	11.70	11.62	.08	.97
17	31	5341	14558F	10.96	11.30	.34	1.38
18	100	5426	14665F	9.96	9.82	.14	.82
19	100	5428	14666F	12.95	14.01	1.06	1.03
20	100	5429	14667F	8.54	10.00	1.46	1.07
21	100	5430	14668F	9.13	9.79	.66	1.40
22	100	5432	14664F	13.33	10.53	2.80	1.51
23	Extra	4378	12445	12.32	11.93	.39	.69
24	Extra	4379	12517	8.85	8.17	.68	.13
25	Extra	4380	12516F	7.56	7.57	.01	.14
26	Extra	4381	12508	7.75	6.92	.83	.35
27	Extra	4382	12510	10.27	9.91	.36	.49
28	Extra	4383	12506	9.73	9.88	.15	.83
29	Extra	4384	12507	12.90	13.05	.15	1.13
30	Extra	4385	12509	12.95	13.60	.65	.60
31	Extra	4386	12505	12.51	11.81	.70	.38
32	Extra	4387	12479	13.65	12.40	1.25	.82
33	Extra	4388	12480	12.27	14.02	1.75	.65
34	Extra	4389	12468	9.07	10.11	1.04	.68
35	Extra	4390	12467	8.46	7.83	.63	.81
36	Extra	4391	12447	6.79	6.71	.08	.39
37	Extra	4392	12448	6.73	5.23	1.50	.47

TABLE 4.—*Results of tests in a single laboratory to determine accuracy of mine-sampling methods by reference to dry-ash values in final sub-divisions resulting from riffing opposite halves of gross sample*
(Grinder and riffle method)

Table No.	Lab. No.	Co-op. No.	Duplicate halves	CO ₂	Ash	
					Percentage	Difference
1	4933	(a)	a	...	8.27	
2	4933		b	...	8.23	0.04
3	4934	(a)	a	...	10.58	
4	4934		b	...	10.62	0.04
5	4945	(a)	a	...	15.01	
6	4945		b	...	15.41	0.40
7	4947	(a)	a	...	16.07	
8	4947		b	...	16.03	0.04
9	5012	49	a	0.49	11.10	
10	5018	49	b	...	10.69	0.41
11	5013	49	a	...	12.58	
12	5015	49	b	0.76	12.38	0.20
13	5016	49	a	0.49	10.80	
14	5017	49	b	...	11.02	0.22
15	5019	46	a	0.41	9.15	
16	5020	46	b	0.36	8.84	0.31
17	5021	46	a	0.92	9.85	
18	5023	46	b	0.80	9.98	0.13
19	5022	46	a	0.25	9.72	
20	5024	46	b	0.26	9.91	0.19
21	5025	47	a	1.45	13.73	
22	5028	47	b	...	13.61	0.12
23	5027	90	a	...	11.09	
24	5034	90	b	0.70	11.23	0.14
25	5029	47	a	0.83	11.02	
26	5031	47	b	...	11.14	0.12
27	5032	47	a	0.93	12.82	
28	5036	47	b	...	12.61	0.21
29	5277	27	a	1.33	11.91	
30	5280	27	b	...	11.98	0.07
31	5278	27	a	1.10	9.91	
32	5279	27	b	...	9.74	0.17
33	5281	27	a	1.78	12.01	
34	5282	27	b	...	11.80	0.21

TABLE 4—*Concluded*

Table No.	Lab. No.	Co-op. No.	Duplicate halves	CO ₂	Ash	
					Percentage	Difference
35	5292	28	a	1.36	12.01	
36	5301	28	b	...	11.83	0.18
37	5294	28	a	...	12.78	
38	5295	28	b	2.32	12.94	0.16
39	5299	28	a	1.22	10.64	
40	5302	28	b	...	10.66	0.02
41	5306	3	a	0.22	6.58	
42	5308	3	b	...	6.35	0.23
43	5307	3	a	0.70	11.73	
44	5309	3	b	...	11.50	0.23
45	5310	3	a	...	11.22	
46	5311	3	b	1.17	10.62	0.60
					Average difference	
					0.19	
					Maximum difference	
					0.60	
					Second greatest difference. .	
					0.41	

*Preliminary tests preceding the cooperative work.

The agreement of these values is exceedingly concordant and indicates beyond question a satisfactory uniformity in the samples thus obtained. Especially should this feature be compared with the variations shown in Table No. 1, where the same conditions existed in that a single laboratory was involved in obtaining results. On the other hand, there are shown, by inspection of the results in Tables 2 and 3, some of the difficulties involved in securing uniformity in ash determinations in different laboratories, especially in the presence of considerable calcite.

Summary of work of a single laboratory on duplicate samples

Bureau of Mines standard method of sampling

					Difference in percentage			
					-.50	.50-1.00	1.00-2.00	2.00+
I. S. G. S. laboratory (29 pairs)					15	10	3	1
U. S. B. M. laboratory (29 pairs)					22	6	1	..

Grinder and riffle method

I. S. G. S. laboratory (23 pairs)					22	1	..	..
Average difference, 0.19								
Maximum difference, 0.60 (CO ₂ =1.17 per cent)								
Maximum difference, unaccounted for, 0.41								

In the summary above, only the unaccountable differences are listed. Those accompanied by a high-CO₂ content are due presumably to the effect of this constituent.

RIFFLE AS A SOURCE OF ERROR IN SAMPLING

Instead of being a safety appliance for guaranteeing a correct sample, the riffle may be the cause of serious discrepancies if used improperly. This is due to a higher ash and a higher specific gravity of the finer material in a coal sample than of the coarser particles. Unless guarded against, therefore, segregation is likely to occur, and sometimes under conditions where such a result would perhaps be least expected. To illustrate a variable ash content for the fine and coarse coal two sample, Nos. 1 and 2, were divided according to size into 1₁, 1₂, 1₃, and 2₁, 2₂, and 2₃, being respectively in size, 8 to 20, 20 to 60, and finer than 60 mesh. An analysis for ash was made on each size, with results as tabulated in Table 5.

TABLE 5.—*Results of tests to determine the relation of the ash values in dry coal to the size of coal particles in the sample*

Series	Mesh	Duplicate halves	Amount of each size	CO ₂ in "dry coal"	Ash corrected for CO ₂	a and b for each series composited by calculation
			<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	
1 ₁	On 20	a	41.7	.40	14.11	
		b	48.4	.37	14.00	
1 ₂	Through 20 on 60	a	41.7	.85	15.55	
		b	37.9	1.00	15.42	a 16.33
1 ₃	Through 60	a	16.6	1.31	23.89	b 15.86
		b	13.7	1.38	23.65	Aver. ... 16.09
2 ₁	On 20	a	29.1	.53	15.91	
		b	25.0	.46	15.68	
2 ₂	Through 20 on 60	a	48.4	.94	16.23	
		b	51.9	.98	16.06	a 17.90
2 ₃	Through 60	a	22.5	1.32	24.09	b 17.80
		b	23.1	1.28	23.98	Aver. ... 17.85

Note that there is approximately a 50 per cent increase in ash for the finest size over that for the coarsest division, and that the amount of fine material thus affected is from 14 to 23 per cent of the whole. This feature of varying ash content is thus well illustrated, and its effect upon segregation and subsequent irregularities in the sample is likely to be underestimated.

In the use of a riffle, if the material is added from the scoop more rapidly than it can pass through the openings, thereby piling up in the

rifle hopper, the material tends to form itself into cone-shaped masses, down the sides of which the particles may flow more readily in one direction than in another, depending on the freedom of the opening. Such conditions promote marked segregation. In order to test this process experimentally four portions of the same sample were riffled rapidly as described above. The results from the duplicate subdivisions 1a and 1b are as shown in Table 6 in comparison with a slower feeding of the rifle in such a manner as not to cause any piling up of the material above the slots.

TABLE 6.—*Comparison of ash values from rapid and slow feeding of rifle*

Sample	Ash values from rapid feeding of rifle	Ash values from slow feeding of rifle
1a	14.35	16.07
1b	17.87	16.26
Difference	3.52	0.19

TABLE 7.—*Comparison of variations of ash values in duplicate samples resulting from careless feeding of rifle with those resulting from careful feeding^a*

Duplicate portions	Careless feeding			Careful feeding		
	Lab. No.	Percentage	Difference	Lab. No.	Percentage	Difference
a	8570	13.41		8606	15.09	
b	8571	14.21	0.80	8607	15.36	0.27
a	8583	15.21		8614	21.71	
b	8584	16.59	1.38	8615	20.86	0.25
a	8586	14.82		8617	21.31	
b	8587	13.99	0.83	8618	21.12	0.19
a	8593	14.83		8623	18.08	
b	8594	16.22	1.39	8624	17.84	0.24
a	8596	14.74		8626	17.00	
b	8597	14.24	0.50	8627	16.75	0.25
a	....	....	....	8635	16.26	
b	....	....	....	8636	16.26	0.00
a	....	....	....	8638	15.41	
b	....	....	....	8639	15.54	0.13
Average variation..... 0.98				Average variation..... 0.19		

^aDuplicate samples were taken from opposite halves of the same gross sample.

As further evidence, and to avoid basing a conclusion upon insufficient data, a series of experiments was conducted in which two different methods of rifle feeding were used. The results are shown in

Table 7. It should be stated that the duplicate samples employed were reduced from opposite halves of the same gross sample instead of being merely opposite halves of the last subdivision. The results, therefore, serve also to indicate that discrepancies which are sometimes attributed to faulty handling of the gross sample may be in reality due to an error in the method of reducing the sample in the laboratory—for example, a faulty manipulation of the riffle.

STUDY OF CERTAIN LABORATORY PRACTICES AND CORRECTIONS

COAL-ASH DETERMINATIONS

ASH VALUES AS AFFECTED BY THE QUANTITY TAKEN FOR FINE GRINDING

The previous discussion of the variables that may be introduced through a faulty procedure in the matter of obtaining the various subdivisions in the mine suggests the advisability of making reference to a closely related item, that of the quantity taken for the final grinding to 80-mesh size in the laboratory.

Two general methods are recognized: one, in which the fine grinding of 2 ounces or 60 grams is accomplished by means of the bucking-board; the other, in which about 500 grams is ground in a ball mill. A comparison of the two methods has been afforded by the studies on the variables connected with riffing. These are presented as furnishing an argument in favor of the larger sample, though it affords at the same time good evidence of the reliability of the method using the smaller sample, provided proper care is taken in the riffing processes. Neither method can be expected to overcome the errors which may be introduced by faulty riffing. It is true the difference in the two procedures, as shown in the table, is not great, but the evidence, so far as it goes, is in favor of the use of the ball mill, doubtless because of the greater quantity employed. The comparative results are shown in Table 8.

TABLE 8.—*Comparison of duplicate values for dry ash as obtained from the fine grinding of 60 grams on the buckboard and of 500 grams on the ball mill*

Lab No.	Duplicate halves	Percentage of ash			
		Buckboard used	Difference	Ball mill used	Difference
8606	a	15.09		15.37	
8607	b	15.36	0.27	15.10	0.27
8614	a	21.11		21.10	
8615	b	20.86	0.25	21.07	0.03
8617	a	21.31		21.23	
8618	b	21.12	0.19	21.21	0.02
8623	a	18.08		17.69	
8624	b	17.84	0.24	17.73	0.04
8626	a	17.00		16.76	
8627	b	16.75	0.25	16.66	0.18
8635	a	16.26		16.53	
8636	b	16.26	0.00	16.66	0.16
8638	a	15.41		15.76	
8639	b	15.54	0.13	15.56	0.20
8668	a	20.04		19.88	
8669	b	19.80	0.24	19.72	0.16
8671	a	18.13		17.78	
8672	b	17.84	0.29	17.58	0.20
Average differences			0.21		0.14

ASH VALUES AS AFFECTED BY CALCIUM-BEARING MINERALS

OCCURRENCE OF CALCIUM SULPHATE AND CALCIUM CARBONATE

Upon examination, the white flakes which so frequently appear in the cleavage planes of Illinois coal, are found to be either calcium carbonate or calcium sulphate. They may be distinguished by the differences in appearance of these compounds, the sulphate being of a dead or "flat" white without lustre or suggestion of translucence, whereas the calcite is much more vitreous and is semi-transparent if held up to the light. Figure 4 shows two large characteristic flakes of calcium sulphate. Figure 5 shows a number of plates of calcium carbonate.

GEOGRAPHIC DISTRIBUTION OF CALCIUM CARBONATE

In previous publications¹ the analytical results for carbon dioxide and calcium carbonate are given for fifty Illinois coals. These results, together with carbon-dioxide values presented in the analytical table, No. 25 of this bulletin, furnish data on this item for approximately 400 samples, a number sufficient for a study to determine whether cal-

¹Parr, S. W., Composition of Illinois coal: Ill. State Geol. Survey Bull. 16, p. 232, 1910; also, Proceedings Eighth International Cong. Applied Chem., vol. X, p. 215.

cite deposition is a characteristic of certain areas or whether it is irregular and more or less accidental in its occurrence.

As the readiest method for arriving at a conclusion on this point, a map was prepared giving by means of symbols the localities where carbonates occur and also some idea of the amount present. From this

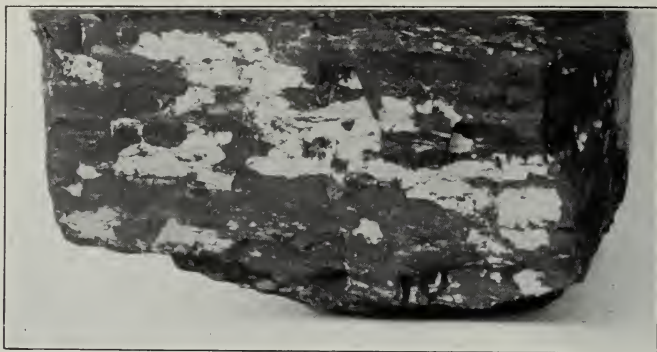
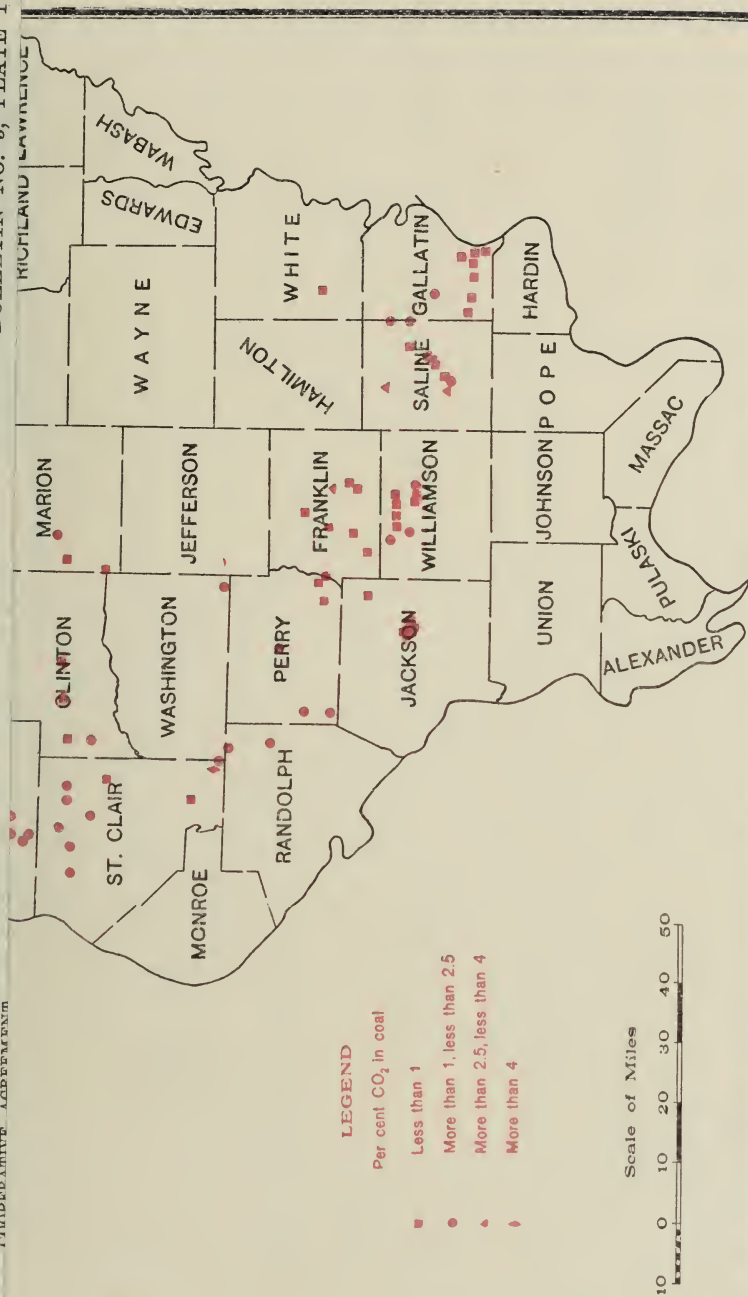


FIG. 4.—Coal containing large characteristic flakes of calcium sulphate.

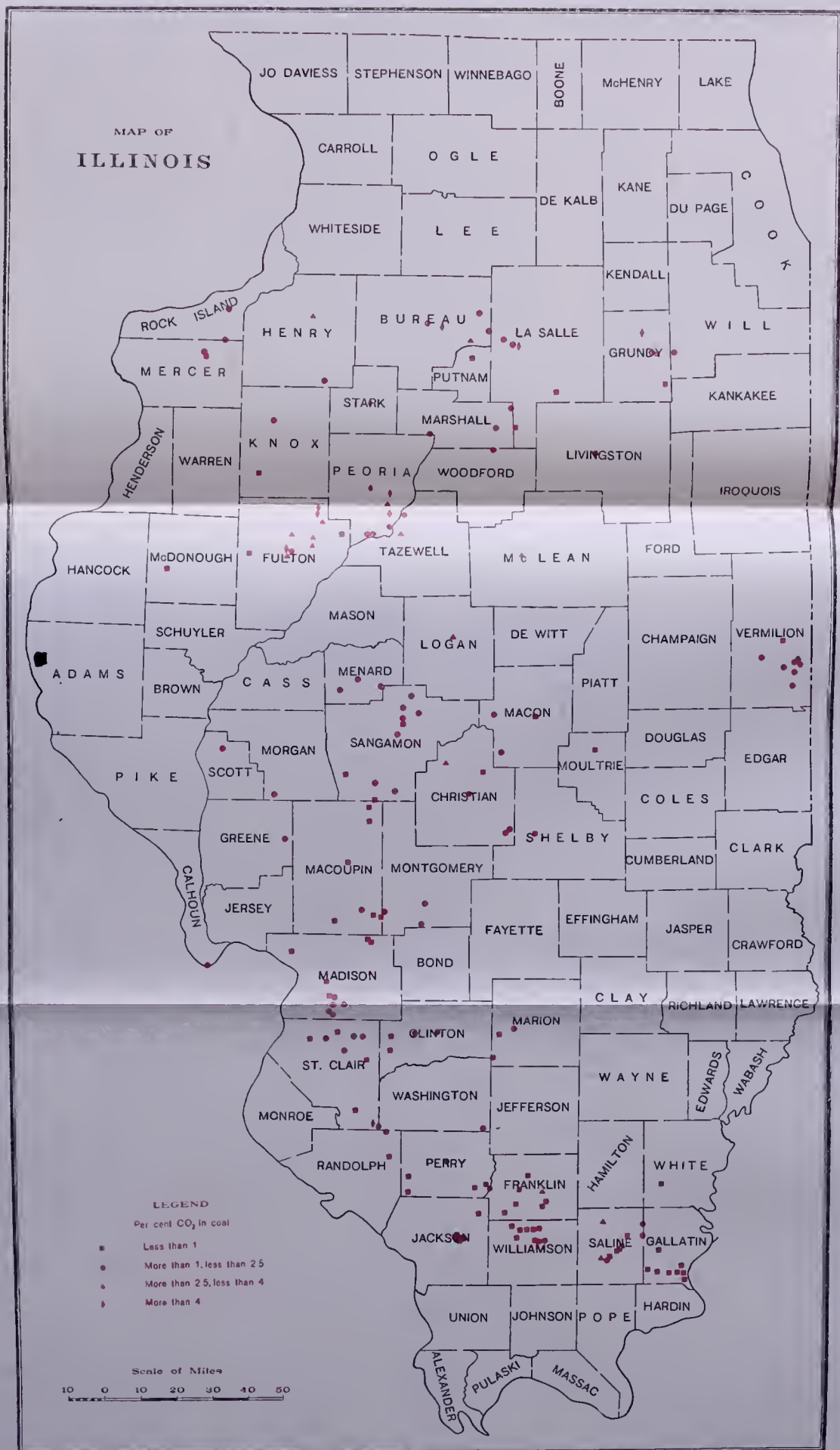


FIG. 5.—Coal containing a number of plates of calcium carbonate.

chart it is evident that the calcite is widely distributed throughout the coal beds of the State with hardly any reference to associated geological conditions. A zone of somewhat greater intensity, as shown by a higher average in the percentage content, seems to be indicated for Fulton and Peoria counties, whereas a lower average is indicated for the counties of Williamson, Saline, and Gallatin.



Map of Illinois showing distribution of calcium carbonate in coal



Map of Illinois showing distribution of calcium carbonate in coal

However, it should be noted that not infrequently the same mine yields samples which differ widely in their content of carbon dioxide. Compare for example the various samples from the same mine under coal No. 1, Mercer County, cooperative samples 17, 18, and 19; coal No. 2, Bureau County, cooperative sample 8; coal No. 5, Fulton County, cooperative samples 31 and 29; coal No. 5, Saline County, cooperative sample 48; coal No. 6, Franklin County, cooperative sample 53. Some of these samples have from two to seven times as much carbonate as others from the same mine. This is doubtless the condition to be expected from the method of formation in the cleavage planes. Infiltration of ground waters, which is likely to be more or less facilitated by jointing of the overlying strata, would result in an uneven distribution of this material.

AMOUNT OF CALCIUM CARBONATE IN ILLINOIS COALS

As a result of work on the 400 samples mentioned above, it appears that only 30 coals, or about 9 per cent of the total collection, yield carbon dioxide in an amount less than 0.1 per cent. This represents less than 0.2 per cent of calcium carbonate, the form in which the CO_2 occurs. Nearly 50 per cent of the samples have calcium carbonate present in excess of 1.0 per cent of the raw coal, 20 per cent have more than 2.0 per cent of the carbonate, and 3 per cent have over 4 per cent of this constituent. These ratios substantially duplicate results in the previous series of 122 samples which were published together with the method and description of apparatus for making the determinations. In one extreme case in each series the calcium carbonate exceeded 8 per cent of the coal substance. In view of the results as thus enumerated no argument is necessary as to the advisability of taking note of this constituent and including it in the list of substances determined, at least with Illinois coals.

DISTURBING EFFECT OF CALCIUM CARBONATE

To illustrate the variable effect of high calcium carbonate on ash determinations, a certain coal was subjected to ashing by ordinary methods, but with slight variations in the type of container and the temperature employed. It gave results varying in the extreme by over $2\frac{1}{2}$ per cent. The sample, No. 6123, had 4.92 per cent of calcium carbonate, calculated on the basis of 2.17 per cent CO_2 as determined. It had also 0.19 per cent of sulphate, calculated as SO_3 . The conditions and results were as follows:

Variations in ash determinations

	<i>Per cent</i>
In small porcelain crucible, 23 mm. high, 30 mm. diameter, capacity 7 cc. using various temperatures obtained by blast and muffle—estimated 800-900°.	22.25
	21.85
	22.67
	21.93
	22.25
	20.84
	21.31
In shallow milk dish in muffle, at an estimated temperature of 900-950°.	21.03
	19.96
	19.94

RELATIONS OF CALCIUM OXIDE AND SULPHUR

The above results suggest a number of questions: Does the presence of calcium oxide affect the behavior of sulphur? Will pyritic sulphur be transferred to the lime as sulphide or as sulphate? Will the sulphates when present dissociate and liberate SO_3 , or combine with the lime and be more likely to remain in the ash? Can the CO_2 as volatile ash be completely eliminated and satisfactorily corrected for, so as to contribute to the accuracy of other factors calculated by difference?

It may be well at this point to present briefly some evidence that the CO_2 as determined is in actual combination as CaCO_3 or MgCO_3 . For this purpose the acid solutions from the CO_2 determinations were analyzed for their content of calcium and magnesium, and always yielded a full equivalent for the CO_2 . Indeed, these bases were present in slight excess, being doubtless in combination as silicates. The results are shown in Table 9.

TABLE 9.—*Results of analyses for calcium and magnesium in the acid solution after determination of CO_2*

Lab. No.	Moisture	Ash	CaO	MgO	CO_2	CO_2 required for $\text{CaO} + \text{MgO}$
6401	2.57	24.64	3.18	.12	2.21	2.62
6402	3.06	26.40	3.49	.15	2.60	2.90
6403	2.78	25.35	3.14	.12	2.24	2.59
6404	3.14	22.94	2.85	.10	2.10	2.35
6405	3.28	22.77	2.81	.12	2.05	2.33

The presence of these quantities of calcium oxide in the ash would suggest the tendency of this material to absorb sulphur from the iron pyrites. Since numerous tests for sulphides in the ash have failed to

show any sulphur retained in that form, it is evident that if any sulphur remains it has reached the final stage of calcium sulphate, and a similar result would be expected from the effect of a gas flame which had any considerable quantity of sulphur present. The following table will show such an increase of sulphur as sulphate in the process of ashing:

TABLE 10.—*Analyses on dry-coal basis showing amount of pyritic sulphur absorbed by CaO during incineration*

Lab. No.	Total sulphur in coal	CO ₂	SO ₃ in fresh coal	SO ₃ in ash
6399	3.65	2.49	.21	1.45 1.67 1.82
6400	3.19	2.40	.22	1.42 1.68 1.51

Similarly the weight is affected by an accessible gas flame of coal gas having the usual sulphur compounds present. The following test will serve as an illustration.

TABLE 11.—*Analyses showing increase in weight of ash due to absorption of SO₃ from gas flame*

Lab No.	CO ₂	Wt. of ash as obtained out of contact with gas flame	Wt. of ash exposed 10 min. to gas flame at about 950°	Wt. of ash exposed 20 min. to gas flame at about 950°
6399	2.49	21.78	21.83	21.95
6399	2.49	22.58	22.70	22.82
6400	2.40	20.15	20.33	20.44
6400	2.40	21.19	21.26	21.33

DISSOCIATION OF CALCIUM CARBONATE AND CALCIUM SULPHATE

The question would naturally arise at this point as to whether it would be possible to obtain the ash of coal without decomposition of the calcium carbonate. As part of the answer to this question there is presented in figure 6, the dissociation curve for CaCO₃ as derived from the plotting of Reisenfeld's² values for vapor pressures at different temperatures for that substance. From this figure it would appear that if the ashing could be carried out at a temperature between 500°

²Journal de chimie physique 7, p. 561 (1909).

or 600° the decomposition of the CaCO_3 would be reduced to the minimum and no appreciable absorption of sulphur by CaO would take place.

An attempt was made, therefore, to control the behavior of the SO_3 normally present in the coal and at the same time prevent an increase of this constituent which would result from a combination of

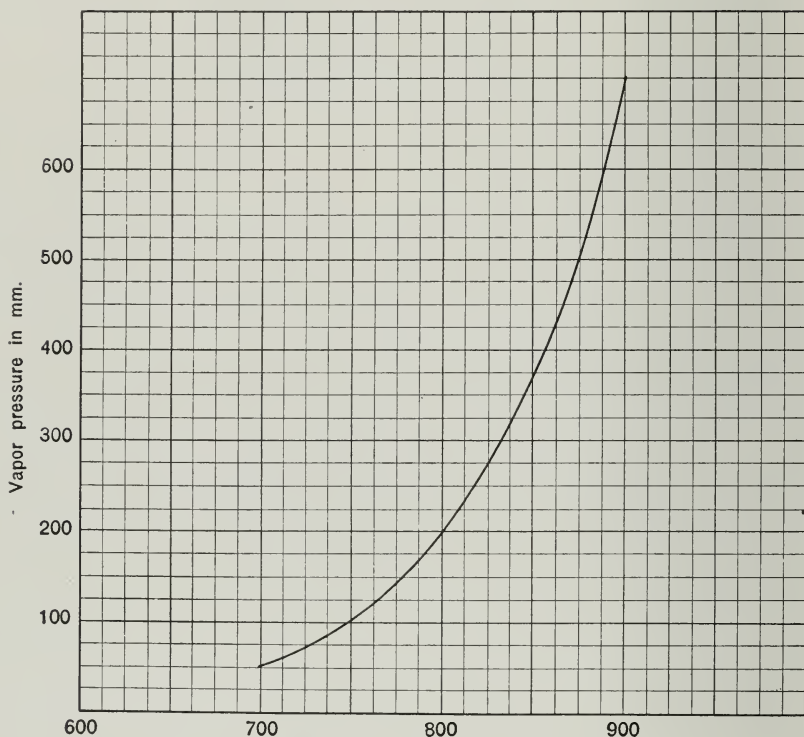


FIG. 6.—Dissociation curve for calcium carbonate.

the sulphur of the pyrites with any CaO which might develop from decomposition of the calcite.

The conditions indicated would seem to call for the burning off of both the carbon and the pyritic sulphur at so low a temperature as to leave the CaCO_3 practically undisturbed. After those reactions were completed the heat could be increased, but only to a point where there would be no appreciable decomposition of the normal content of SO_3 . The procedure, therefore, made use of shallow incinerating dishes over a low flame, the heat having been kept at the lowest pos-

sible point, probably between 500° and 600° . By continuing in this manner for from three to four hours this part of the reaction was practically complete. The dishes were then put in a hot muffle having a temperature of 800° to 850° . This would decompose the CaCO_3 , but at a time when there could be no further reaction by combination of pyritic sulphur with the resulting CaO . To determine the uniformity of the behavior of these reactions, the SO_3 finally present in the ash is compared with the initial SO_3 of the coal, and shown in Table 12. Whereas the results are excellent and the possibilities encouraging, the care and time necessary are prohibitive.

TABLE 12.—*Results of controlling reactions by low-temperature incineration to prevent an increase of sulphate in ash*

Lab. No.	CaO calculated from CO_2 in fresh coal	SO_3 in fresh coal	SO_3 in ash after very low temperature for burning off carbon and S in FeS	SO_3 lost or gained in ashing
5365	1.16	.95	.94	-.01
5367	1.02	.39	.38	-.01
5370	1.46	.47	.48	+.01
5372	.45	.63	.62	-.01
5376	.36	.61	.59	-.02
5388	1.18	1.42	1.40	-.02
5391	.43	.62	.60	-.02
6303	1.83	..	..	..
6304	.56	.31	.31	.00
6305	.50	.26	.26	.00
6306	2.15	.21	.21	.00
6307	2.70	.27	.27	.00
6308	1.44	.20	.20	.00
6309	1.37	.33	.32	-.01
6310	.95	.21	.22	+.01
6311	.53	.27	.27	.00
6312	1.25	.18	.18	.00

From the experience thus outlined it would seem that a practicable method of ashing where calcium carbonate is involved must be based on a temperature in excess of 700° . In addition, therefore, to decomposing the calcium carbonate, there would be a more or less complete replacement of the CO_2 by SO_3 , resulting in the formation of calcium sulphate. The question of the stability of this substance is therefore involved.

As to the decomposition of CaSO_4 , no values for vapor pressure at different temperatures are at hand. From the decrease in the weight of ash and the corresponding decrease in SO_3 as shown in Table 13, we

TABLE 13.—*Amount of decomposition of CaSO_4 in coal ash at temperatures varying from 700° to 1050° Centigrade*

Conditions	Portions of coal sample No. 6305			
	1	2	3	4
Wt. of ash and H_2SO_4 heated for 10 minutes at 700° In muffle at 700°	20.97	20.94	20.83	20.90
Wt. of ash, second period, 10 minutes.....	20.97	20.83	20.83	20.84
Wt. of ash, third period, 10 minutes.....	20.97	20.83	20.83	20.84
SO_3 , by analysis, per cent.....	....	....	3.48	3.52
In muffle at 815°				
Wt. of ash, first period, 20 minutes.....	20.77	20.56	....	....
Wt. of ash, second period, 30 minutes.....	20.65	20.48	....	....
Loss in wt. per cent.....	.32	.35	....	....
SO_3 loss by analysis, per cent.....	.33	.34	....	....
In muffle at 950°–1050°				
Wt. of ash after 38 minutes.....	....	....	....	19.79
Loss in wt. per cent.....	....	....	....	1.11
SO_3 loss by analysis, per cent.....	....	....	....	1.08

may construct a curve (fig. 7) which will show in general the behavior of this material through the various ranges of temperature likely to be considered in this connection.

METHOD FOR CONTROLLING AND CORRECTING ASH DETERMINATIONS FOR CALCIUM CARBONATE

General considerations.—From the experiments thus shown we have evidence that at a temperature of 700° to 750° the loss of SO_3 by dissociation is practically negligible. At higher temperatures, however, an appreciable loss occurs. From a study of all the elements of the case, considering especially time, practicability, and temperatures, it would seem that the following general outline of procedure is indicated.

Coals with relatively low calcium carbonate.—If the calcium carbonate is small in amount the following procedure will result in a negligible error. It is recommended that ashing be carried on in a shallow incinerating dish³ over a low flame until practically all of the carbon is burned out. The temperature toward the end may be raised nearly to dull redness, but for the most part should not be more than 500° to 600°. The time involved for this part of the process need not exceed one-half hour. Occasional stirring with a platinum or nichrome wire will facilitate the burning out of the carbon. Second, if the

³Such dishes as are listed under the name of "Glüh-Schälchen," No. 5837 in Greiner & Friedrich's catalog, 1912.

capsule is transferred to a cherry-red muffle maintained at 700° to 750° there should be no alteration in constituent except the CaCO_3 . Moreover, the preliminary burning should dispose of the pyritic sulphur before any sulphate could become fixed.

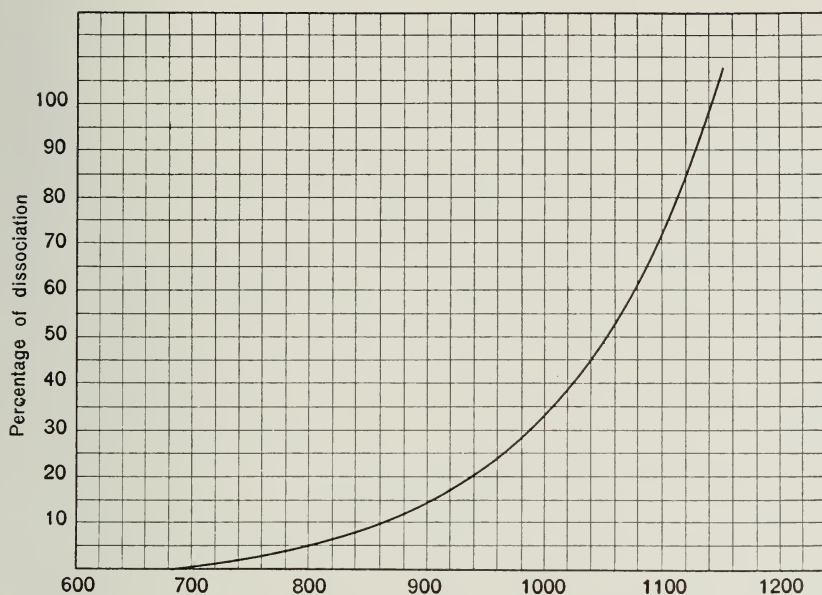


FIG. 7.—Dissociation curve for calcium sulphate.

Coals with relatively high calcium carbonate.—If the calcium-carbonate content is high, and especially where extreme accuracy is desired, a correction for loss of CO_2 should be secured as follows.

For coals containing carbon dioxide in an amount to call for correction, say 0.5 to 1.00 per cent and over, the ash after the preliminary burning off of the carbon and cooling is moistened with a few drops of sulphuric acid (diluted 1:1) and again after drying brought up to 750° C. and retained at that temperature for 3 to 5 minutes. The capsule is cooled in a desiccator and weighed. Three times the equivalent of carbon present as carbon dioxide is subtracted from the ash as weighed in order to restore the weight of the calcium sulphate formed to the equivalent of calcium carbonate. The ratios in molecular equivalents are

$$\begin{array}{rcl}
 \text{SO}_3 & = & 80 \\
 3\text{C} & = & 36 \\
 \hline
 \text{Difference} & & \\
 \text{as } (\text{CO}_2) & = & 44
 \end{array}$$

The above method was applied in the determinations of ash on five coals high in calcium carbonate. The results are given in Table 14.

TABLE 14.—*Analyses showing agreement of ash duplicates in high-carbonate coals resulting from treatment of carbon-free ash with H_2SO_4 and reburning at 700° to 750° Centigrade*

Lab. No.	A H ₂ O	B Duplicate ash from H ₂ SO ₄ treatment	C Original SO ₃ in untreated coal	D CO ₂ found in fresh coal	E SO ₃ equivalent to CO ₂ as shown in column D	F SO ₃ as determined in treated ash with subtraction of original SO ₃ as shown in column C	G Difference between corrected value and original CO ₂ value
6401	2.57	24.61 24.67	.16	2.21	4.08	4.16	.08
6402	3.06	26.46 26.33	.18	2.60	4.81	4.67	.14
6403	2.78	25.51 25.20	.16	2.24	4.14	4.13	.01
6404	3.14	22.96 22.93	.16	2.10	3.88	3.84	.04
6405	3.28	22.71 22.81	.20	2.05	3.79	3.72	.07

Since the resulting sulphate was determined as SO₃, the CO₂ present was calculated to the SO₃ equivalent and comparison for the treated ash made on that basis. The variations as indicated in column G are of a low order and indicate the reliability of the method for correcting the ash in high-carbonate coals.

In Table 15 are given the original moisture and calcium carbonate in the samples together with the ash determined by the usual method and also by the H₂SO₄ method which corrects the result for calcium carbonate.

ASH VALUES AS AFFECTED BY SULPHATES

Occurrence and behavior.—From the foregoing studies involving variations due to the formation of sulphates and their possible decomposition under conditions of temperature or a reducing atmosphere it seemed advisable to make a further study of the occurrence of this ingredient in coal. If sulphates are initially present in the form of sulphates of iron there is involved their possible decomposition from that combination. The dissociation temperature for ferrous sulphate begins at 550° and is rapid at 600°. Ferric sulphate is indicated as

TABLE 15.—*Ash values as determined by the usual method compared with corrected values taking account of calcium carbonate*

Lab. No.	Moisture	Calcium carbonate	Ash by routine method	Ash by treatment with H_2SO_4	Difference
6401	2.57	5.03	20.76		
			20.14		
			21.76	24.61	
			21.78	24.67	
			Average 21.61	Average 24.64	3.03
6402	3.06	5.91	22.41		
			22.45		
			23.07	26.46	
			23.30	26.33	
			Average 22.81	Average 26.40	3.59
6403	2.78	5.10	21.35	25.51	
			21.19	25.20	
			Average 21.32	Average 25.36	4.04
6404	3.14	4.78	22.52		
			21.73		
			20.26		
			20.03		
			19.80	22.96	
			20.48	22.93	
			Average 20.80	Average 22.94	2.14
6405	3.28	4.66	19.63	22.71	
			19.64	22.81	
			Average 19.64	Average 22.76	3.12

decomposing at 700° . Calcium sulphate has already been discussed and, as noted, would not be disturbed by the proposed method for ashing.

With reference to the amount and distribution of sulphate, from the limited data obtained up to the present time the indications are rather unexpected, and to the effect that this ingredient is about as common and in sufficient proportions to be as seriously disturbing as has been found to be the case with carbonates. This may be illustrated in Table 16 showing the percentage, amount, and distribution of SO_3 in dry coal for 18 samples.

Increase of sulphates in laboratory samples.—A closely related phase of this matter is the growth of sulphate in finely divided coal. This is especially noticeable in the laboratory samples ground to 60-mesh size, even when kept in the most approved manner in glass containers with rubber stoppers. That this finely ground material is chiefly involved in this change is shown by the following experiment.

TABLE 16.—*Analyses showing amount of sulphate in fresh samples of Illinois coals; values in percentage of dry coal*

Lab. No.	County	CO ₂	Sulphate present as SO ₃
5365	Mercer	0.91	0.95
5367	Grundy	0.80	0.39
5370	Mercer	1.15	0.47
5372	Mercer	0.35	0.63
5376	Grundy	0.28	0.61
5388	La Salle	0.93	1.42
5391	La Salle	0.34	0.62
6304	Sangamon	0.44	0.31
6305	Williamson	0.39	0.26
6306	Vermilion	1.69	0.21
6307	Vermilion	2.12	0.27
6308	Vermilion	1.13	0.20
6309	Christian	1.08	0.33
6310	Sangamon	0.75	0.21
6311	Williamson	0.42	0.27
6312	Sangamon	0.98	0.18
4994	Saline	0.00	0.72
5123	Williamson	0.07	0.32

Seven samples of coal were analyzed in August, 1912, for SO₃, by taking the fresh sample ground to 60-mesh and digesting it in 10-per cent solution of hydrochloric acid. In April, 1913, portions of the same laboratory sample, that is of 60-mesh size, were similarly analyzed for sulphate and at the same date portions of the coarse material as originally received, one pound of which had been retained in a "lightning" or "seal fast" jar with lever clamp top. These gross samples had been reduced to about 10-mesh size and air dried, though some of the numbers had a larger portion of fine material than others, noticeably in the fourth sample, No. 5372. The results are shown in the following Table 17.

TABLE 17.—*Analyses showing comparison of growth of sulphate in fine and coarse stored laboratory samples*

Lab No.	County	H ₂ O	Total sulphur	SO ₃		
				60-mesh Aug., 1912	60-mesh April, 1913	10-mesh April, 1913
5365	Mercer	6.33	5.29	.95	1.46	.86
5367	Grundy	8.84	2.27	.39	.38	.18
5370	Mercer	4.49	4.92	.47	.49	.25
5372	Mercer	4.86	5.46	.63	1.25	1.12
5376	Grundy	7.66	2.73	.61	1.12	.86
5388	La Salle	7.93	5.20	1.42	1.79	.82
5391	La Salle	8.05	4.83	.62	1.20	.81

An inspection of this table will indicate that as between the freshly ground coal and that which had been kept in laboratory storage for eight months the increase in sulphate was exceedingly marked in all but the second and third samples. Also with one exception, the coarser material had a lower percentage of sulphate. This suggested a further test wherein two of the numbers having high-sulphate factors were sized, namely Nos. 5372 and 5388. Sulphate determinations were accordingly made on the several fractions, of 10-, 20-, and 40-mesh, with results as shown in Table 18.

TABLE 18.—*Analyses showing content of sulphate present as SO_3 in sized portions after eight months in storage*

Lab. No.	10-mesh	20-mesh	40-mesh
5372	.91	.89	1.43
5388	.53	.60	1.42

It is indicated in this table that although substantially no increase in sulphate has occurred up to the 20-mesh size, the growth of that substance has been very marked in the 40-mesh portion, though it should be said that the 40-mesh contains also all of the material passing through that sieve.

In seeking an explanation for the lack of uniformity in behavior due to sizing alone, it was thought that possibly the amount of free moisture in the sample as well as the percentage of FeS_2 might play an important part. A number of samples were, therefore, selected in which the free moisture was low. In these cases the growth of sulphate in the laboratory sample was small, as shown in Table 19.

TABLE 19.—*Analyses showing effect of low moisture on the development of sulphate in stored laboratory samples*

Lab. No.	H_2O	Sulphur (dry-coal basis)	Percentage of SO_3					
			60-mesh laboratory sample stored $2\frac{1}{2}$ mos.	Sample selected from reserve sample after $1\frac{1}{2}$ mo.	Sample selected from reserve after $2\frac{1}{2}$ mos.	10-mesh of reserve sample	20-mesh of reserve sample	40-mesh of reserve sample
6399	1.74	3.65	.214	.200	.198	.176	.164	.215
6400	2.03	3.19	.218	.230	.228	.199	.195	.257

A further interest attaches to sample No. 5372, which has been listed in Tables 16 and 17 above, in that the accumulation of sulphate of iron in this sample has become so marked as to be clearly shown in

the sample bottle. A photographic illustration is given in which an attempt is made to show the white formation of sulphate on the bottom of the bottle, some of it in crystalline form (fig. 8).



FIG. 8.—Formation of sulphate crystals on bottom of sample bottle.

Figure 9 is a photomicrograph of a small mass taken from a sample of coal enclosed in a museum jar. The sample had not been air dried, and all of the normal moisture was present when it was first put into the jar. The sulphate crystals were quite abundant throughout the coal mass. Of course the white deposit of iron sulphate over the surface of a pile of screenings which has been exposed to the weather is



FIG. 9.—Photomicrograph of sample of coal enclosed in museum jar showing crystals of sulphate.

not unusual, but ordinarily we have not thought to look for the same effect in carefully sealed laboratory containers.

In order to secure further evidence on the relation between free moisture and sulphate in sealed samples, 28 samples of coal were selected from the various districts of the State and sulphate determination made on the laboratory samples ground to 60-mesh which had been in storage from the early part of 1912 until June, 1913. Unfortunately the sulphate factors for the fresh coal are not available, but the table shows that high moisture, especially when accompanied by a high percentage of total sulphur, presumably mainly in the sulphide form in the fresh coal, will produce upon standing a high percentage of sulphate sulphur. This would normally proceed from the equation $2\text{FeS}_2 + 7\text{O}_2 + 2\text{H}_2\text{O} = 2\text{FeSO}_4$. Note in this connection especially Nos. 5359, 5361, 5362, and 5364 of Table 20.

TABLE 20.—Amount of sulphate in laboratory samples stored from March, 1912, to June, 1913, and attending conditions of moisture and sulphur^a

Lab. No.	County	Coal bed	H ₂ O	Total sulphur	SO ₃ (dry-coal)
4699	Vermilion	6	2.30	2.44	.18
4702	do	6	2.08	2.75	.15
4706	do	6	2.08	3.48	.32
4707	do	6	1.82	4.82	.35
4716	do	7	2.31	4.06	.62
4724	do	7	1.95	3.77	.60
4727	do	7	1.91	3.33	.37
4734	do	7	2.24	2.59	.22
4744	do	6	4.58	1.94	.29
4789	Franklin	6	3.88	.52	.02
4811	do	6	2.41	1.53	.22
4994	Saline	5	2.82	2.32	.54
5006	Williamson	6	3.25	1.11	.12
5011	Franklin	6	4.14	1.53	.18
5024	Saline	5	5.87	3.78	.80
5121	Williamson	6	3.73	1.42	.11
5122	do	6	6.25	1.46	.12
5134	do	6	6.25	1.24	.10
5224	Franklin	6	5.87	1.12	.06
5339	Mercer	1	3.21	5.66	.98
5359	Rock Island	1	4.84	6.56	2.14
5361	do	1	5.74	4.56	1.08
5362	do	1	4.96	5.26	1.15
5364	Mercer	1	6.34	4.94	1.69
5368	Grundy	2	7.08	3.04	.59
5369	do	2	6.98	2.53	.44
5377	do	2	7.83	4.00	1.34
5389	La Salle	2	7.71	3.57	.83

^aSulphate was determined June 2, 1913, on samples collected Feb. to June, 1912, on pulverized samples.

MOISTURE DETERMINATIONS

METHODS EMPLOYED

It will be of interest at this point to compare the total moistures obtained on the cooperative samples, noting again that the samples of 3 pounds each sent to the laboratories at Pittsburgh and Urbana were obtained as shown in figure 1. The methods employed by the two laboratories differed somewhat and since the coals under consideration are of the high-moisture type, an excellent opportunity is offered for testing out the methods employed since any irregularities in procedure would at once manifest themselves. In the main it may be said that the results as obtained by the two laboratories are in very good agreement, and where large variations occur there is an evidence in the accompanying data as to the cause, and in consequence a suggestion as to the remedy.

The methods differed in that the Bureau of Mines uses smaller pans for air drying and makes use of the ball-mill, pulverizing by that means about 500 grams of coal to 60-mesh. The University of Illinois method for air drying uses pans 20 by 20 inches. In both laboratories the temperature for air-drying ranges from 35° to 40° C. The moisture in the air-dry sample in consequence rarely exceeds 3 per cent. In this condition it is reduced to 10-mesh in a grinder of the coffee-mill type, passed entirely through a riffle with 1/4-inch slits until a 60-gram sample results. The material in this small portion which will pass a 60-mesh sieve, about one-third in amount is first separated by use of a closed sieve, and is transferred at once to a 4-ounce rubber-stoppered bottle. The remaining portion is reduced on the bucking board until all passes the same sieve, when it is added to the part already in the 4-ounce bottle. The total time required for the bucking-board process does not exceed three minutes. The grinding and riffing of the gross sample requires also about three minutes.

COMPARISON OF THE RESULTS

If we accept as suggested in the preliminary report of the Committee on Coal Analysis⁴, a variation of 0.5 per cent as between different analyses for coals of this type, the results on the first 54 samples of Table 21 are reasonably concordant. Certainly the three or four results that vary to the extent of 0.6 per cent or over could not be taken as an argument for or against either method of grinding. For the twenty-three samples following the first fifty-four, however, there are only seven that would come within the prescribed limit of variation.

⁴Year Book for 1915, Amer. Soc. Testing Materials, pp. 596-624.

An examination of the figures in the Bureau of Mines column, showing the amount of moisture retained by the air-dry sample suggests an explanation for the discrepancy. Samples 1 to 56 inclusive have percentages of air-dry moistures, as shown by both laboratories, which are relatively low in amount and presumably somewhere near an equilibrium with the average humidity of the atmosphere. Beginning with sample 57, however, the amount of moisture retained by the air-dry samples sent to the Bureau of Mines is high and in the majority of cases the percentage would seem to be considerably above the point of probable equilibrium with the moisture of the atmosphere. While the variations in total moisture for samples No. 57 to 78 are not altogether consistent, the results seem to indicate that coals with more than 4 or 5 per cent moisture in the air-dry state will lose an appreciable amount of water in the process of grinding. Exemption from the difficulty is not wholly secured by use of the ball-mill in carrying on the process of fine grinding.

TABLE 21.—Comparison of total moisture values in duplicate sets of samples as obtained by the Illinois State Geological Survey and the United States Bureau of Mines

Table No.	Laboratory Nos.		Co-op. No.	Moisture in air-dry sample		Total moisture in coal as received		Excess of percentage values	
	I. S. G. S.	U. S. B. M.		I. S. G. S.	U. S. B. M.	I. S. G. S.	Aver.	I. S. G. S.	U. S. B. M.
1	4756	13578	54	3.97	4.68	10.32	10.40	.....	+0.24
2	4757	13585F	54	2.90	5.65	10.34	10.74	.....	
3	4758	13579	54	2.92	5.01	10.74	11.47	.....	+0.96
4	4759	13586F	54	2.79	4.64	10.41	11.60	.....	
5	4760	13580	54	2.96	4.36	10.22	10.67	.....	+0.49
6	4761	13587F	54	2.62	4.28	10.35	10.28	.....	
7	4764	13581	54	2.72	4.45	9.98	10.47	.....	+0.46
8	4765	13588F	54	2.85	4.39	10.17	10.60	.....	
9	4766	13582	54	2.58	4.10	9.64	10.05	.....	+0.28
10	4767	13589F	54	2.68	3.83	10.13	10.27	.....	
11	4768	13583	54	2.70	4.13	10.05	10.75	.....	+0.48
12	4769	13590F	54	2.69	4.83	10.47	10.73	.....	
13	4738	13569	91	3.26	3.25	14.50	14.86	.....	
14	4746	13573F	91	3.41	4.01	15.14	14.57	+0.11	
15	4739	13567	91	3.44	2.83	15.61	15.85	.....	+0.78
16	4742	13571F	91	3.49	3.34	14.50	15.05	.....	
17	4740	13568	91	3.27	3.43	13.58	14.15	.....	+0.56
18	4741	13572F	91	3.82	3.35	13.63	14.17	.....	

19	4699	13469	92	2.30	5.63	15.36	15.16		
20	4704	13471	92	2.52	5.69	15.27	15.12	+0.17	.....
21	4700	13467	92	2.27	3.63	16.11	15.87		
22	4703	13468	92	2.56	3.69	15.70	15.73	+0.10	.....
23	4701	13470	92	2.12	4.27	15.59	15.37		
24	4702	13472	92	2.08	3.67	15.53	15.52	+0.12	.....
25	4668	13436	93	2.17	4.28	13.12	13.28		
26	4670	13443	93	2.06	4.33	13.68	13.23	+0.15	.....
27	4669	13437	93	2.23	4.60	15.69	15.28		
28	4671	13444	93	2.26	4.80	15.50	15.50	+0.20	.....
29	4672	13441	93	2.19	5.77	15.39	15.19		
30	4674	13448	93	2.30	6.71	15.69	15.11	+0.39	.....
31	4673	13439	93	2.38	5.43	14.55	14.79		
32	4676	13446	93	2.46	6.09	14.56	14.92	.....	+0.29
33	4677	13438	93	2.32	5.03	16.24	16.24		
34	4678	13445	93	2.28	5.19	16.06	16.19	.....	+0.06
35	4710	13486	94	2.11	3.92	12.01	12.66		
36	4711	13493	94	2.21	2.86	12.20	12.67	.....	+0.56
37	4712	13487	94	2.28	3.68	12.35	12.64		
38	4713	13494	94	2.33	2.94	12.70	12.45	.....	+0.02
39	4714	13485	94	2.31	3.59	12.76	12.94		
40	4717	13492	94	2.59	3.50	12.33	12.85	.....	+0.31

TABLE 21.—Comparison of total moisture values in duplicate sets of samples as obtained by the Illinois State Geological Survey and the United States Bureau of Mines—Concluded

Table No.	Laboratory Nos.		Co-op. No.	Moisture in air-dry sample		Total moisture in coal as received			Excess of percentage values	
	I. S. G. S.	U. S. B. M.		I. S. G. S.	U. S. B. M.	I. S. G. S.	Aver.	U. S. B. M.	I. S. G. S.	U. S. B. M.
41	4715	13484	94	2.01	3.42	13.04	13.08	13.08	.....	+0.21
42	4716	13491	94	2.31	3.48	12.67	12.85	13.04	.....	
43	4721	13489	94	2.04	2.93	13.28	13.80	13.80	.....	+0.50
44	4724	13496	94	1.95	2.68	13.27	13.28	13.77	.....	
45	4722	13488	94	1.93	2.74	13.53	13.92	13.92	.....	+0.39
46	4723	13495	94	2.01	2.53	13.45	13.49	13.84	.....	
47	4705	13450	95	2.11	5.95	12.30	12.44	12.44	.....	+0.34
48	4706	13452	95	2.08	4.70	11.87	12.09	12.42	.....	
49	4707	13451	95	1.82	5.89	13.14	13.14	13.14	.....	+0.07
50	4708	13453	95	1.93	4.17	13.04	13.09	13.18	.....	
51	4728	13550	97	1.91	4.22	12.92	13.41	13.41	.....	+0.27
52	4734	13554	97	2.03	3.06	13.07	13.00	13.14	.....	
53	4728	13549	97	1.94	3.28	13.36	13.63	13.63	.....	+0.34
54	4734	13553	97	2.24	2.93	13.10	13.23	13.51	.....	
55	4736	13548	97	2.41	3.06	13.41	14.21	14.21	.....	+0.85
56	4737	13552	97	2.21	3.42	13.24	13.32	14.14	.....	
57	5348	14585F	8	5.77	12.24	15.19	14.96	14.96	+0.23	.....
58	5349	14584F	8	6.02	13.38	17.34	16.07	16.07	+1.27	.....
59	5350	14586F	8	6.00	12.52	16.97	15.67	15.67	+1.30	.....

60	5286	14545	15	4.31	5.44	8.32	7.80	+0.53	.....
61	5287	14547	15	4.40	5.76	8.86	8.40	+0.46	.....
62	5288	14546	15	4.88	6.35	8.91	8.88	+0.03	.....
63	5338	14608F	19	3.69	7.37	13.23	12.56	+0.67	.....
64	5339	14606F	19	3.21	8.08	15.24	14.51	+0.73	.....
65	5340	14607F	19	3.61	8.09	15.15	14.16	+0.99	.....
66	5364	14610F	19	6.34	8.68	14.46	14.07	+0.39	.....
67	5365	14611F	19	6.33	8.30	14.07	13.34	+0.73	.....
68	5283	14554F	31	5.45	8.10	15.18	14.99	+0.19	.....
69	5284	14555F	31	5.81	8.81	16.94	16.65	+0.29	.....
70	5285	14556F	31	5.41	8.77	18.42	17.66	+0.76	.....
71	5296	14559F	31	6.25	8.15	16.82	16.24	+0.58	.....
72	5298	14557F	31	7.00	8.10	16.52	15.47	+1.05	.....
73	5341	14558F	31	4.19	8.35	17.37	16.39	+0.98	.....
74	5426	14665F	100	3.90	8.10	10.13	9.57	+0.56	.....
75	5428	14666F	100	4.58	7.48	10.61	9.24	+1.37	.....
76	5429	14667F	100	5.08	8.86	12.31	11.87	+0.44	.....
77	5430	14668F	100	5.02	8.74	12.00	11.02	+0.98	.....
78	5432	14664F	100	4.29	8.31	13.34	10.42	+2.92	.....

ANALYSES OF ILLINOIS COALS

GENERAL STATEMENT

The analyses presented in the latter part of this report are the result of the extended sampling and analytical campaign carried on during the summer and fall of 1912 by the Coal Mining Investigations. As stated before, they represent the results of analysis of a large number of samples taken under like conditions and by the same sampling crews. They furnish excellent criteria for a comparison of coals from different parts of Illinois. Consideration of the results develops some interesting features regarding the free moisture in Illinois coals and the difference in composition between the top bench of coal No. 6 and the remainder of the seam. In the following pages, therefore, these subjects are discussed in detail and there is added a description of the methods of calculating the commercial heat value of a coal as delivered when the ash, moisture, and sulphur content is known.

FREE MOISTURE IN ILLINOIS COALS

The free moisture in Illinois coal varies considerably. In the greater part of the producing area the freshly mined coal has from 12 to 14 per cent of uncombined water. It is evenly distributed throughout the texture of the coal so that there is no appearance of free moisture on the surface of the coal particles. The water, thus held, slowly escapes in the process of preparation and shipment, the amount of loss depending upon weather conditions, length of time in transit, accessibility of air, and size of particles. No definite rule can be given, therefore, as to the drop in moisture likely to occur between the working face at the mine and the storage bin of the user. The loss in weight may vary from nothing to 4 or 5 per cent. In any event, it is a variable which should receive consideration, because of its effect on tonnage and heat values. Obviously the coal with the lower initial moisture will vary the least in transportation, but high moisture coals carried in stock over long periods and sold at retail will lose a very considerable amount of their original weight. The user receives less water and more fuel per ton, and doubtless the dealer adds enough in price to account for the shrinkage in gross weight. From practical or commercial considerations, therefore, the amount of moisture content for given areas, so far as there is any uniformity in the results, is a matter of considerable importance.

It has been suggested that the cuttings from a drill in the process of boring a hole for blasting would furnish a better index of the normal moisture factor for the coal seam than cross-cuttings from the face, since the drill after penetrating several feet into the unbroken

coal would bring out material which had lost none of its original moisture. A number of such samples are presented in Table 22, showing the percentage of moisture in the drillings and in the face samples taken at the same places. A summary of the results shows that, of the eleven samples compared, six are substantially duplicate checks, four of the face samples show a lower amount of moisture, and two show a higher value. From these results, it is fair to conclude that the moisture as found in the face samples taken with the ordinary precautions is a fair index of the normal moisture content of the seam.

TABLE 22.—*Amount of moisture in drill cuttings compared with amount in face samples*

Lab. No.	Co-op. No.	County	Moisture in drill- hole sample	Moisture in nearby face sample
5247	13	Jackson	9.36	9.88
5227	14	Jackson	10.63	8.77
5370	17	Mercer	17.65	17.50
5362	19	Mercer	15.38	14.46
5199	38	Sangamon	14.08	14.10
4980	43	Saline	6.28	6.80
5014	49	Saline	5.65	4.90
4790	53	Franklin	11.03	10.00
4782	53	Franklin	11.89	10.57
5057	79	St. Clair	11.03	10.69
5026	90	Perry	10.69	11.20

ANALYSES OF TOP BENCH OF COAL NO. 6

In certain districts mining coal No. 6 the custom prevails of leaving a portion of the coal as roof. This is designated as top coal and varies greatly in thickness although it is generally less than 20 inches thick.

In this survey 15 samples of top coal were taken, each from a locality in the mine where a sample from the working face was also obtained.

By reference to Tables 26 and 27, we find that the normal moisture of the seam is least in the southern and southeastern counties, Districts II, V, and VI varying from 5 to 9 per cent, whereas the moisture reaches its maximum in the northern areas, especially in District I where the moisture values vary from 15 to 19 per cent.

These variations do not follow any condition which might be supposed to result from the depth of the seam or geological number of the layer. For example, coal No. 2, La Salle County, has an average moisture content of 15.70 per cent, but coal No. 7 in the same county

has an average of 13.56 per cent. This order is reversed, however, in McLean County, where coal No. 2 has an average of 11.26 per cent. and coal No. 5 has 13.22 per cent.

In the southern counties a possible correlation with geological features would seem to be the fact that to the east and south of the Duquoin anticline the amount of free moisture is less than the percentage found to the west and north of that line. For example, the average moisture for Franklin County is 9.04 per cent. For Jackson County it is 9.28 per cent. The Duquoin anticline bends to the west on entering Jackson County so that Murphysboro is situated east of the anticline. Similarly, the average moisture for Williamson County is 9.31 per cent; for Saline County, 6.92 per cent; and for Gallatin County, 4.30 per cent. In the counties west of the anticline, the moisture ranges from about 10 per cent up to almost 15 per cent. It would be difficult with our present knowledge to attempt an explanation for the relatively low average moisture in the area—whether from the method of deposition, kind or extent of bacterial decomposition of the initial organic material, earth pressures, or earth temperatures, it would be impossible to say. Igneous intrusion is locally evident in the “Coal Measures” of the southeastern part of the State, but the evidence of higher temperatures accompanying such intrusion is localized. The most natural explanation would be to ascribe the lower moistures to greater pressure and higher temperature. Further data from similar regions is necessary before final conclusions would be warranted.

The analytical results in Table 23 afford an opportunity for studying the character and comparative value of the coal thus left in the mine. The analysis for each sample of top coal is coupled with the analytical results from the face sample taken nearby. The features to be observed in studying these values are as follows:

1. The moisture is slightly lower as a rule in the top coal. This is doubtless due to longer exposure and resulting opportunity for escape of moisture.

2. The ratio of volatile matter to fixed carbon remains substantially the same in both.

3. Where variations of any consequence occur in the percentage of sulphur, it is usually higher in the top coal.

4. Ash values are frequently so much lower in the top coal as to be especially noteworthy.

5. The heat values for unit coal are substantially the same as for the face sample.

The last two items are of special interest. For example, the exceptional purity of some of the top coal with respect to the ash content emphasizes the danger which may accompany the taking of a hand

sample and having it analyzed as a representative portion of the output of the mine. A sample of top coal in many cases would give very erroneous results if taken as the average output of the mine.

TABLE 23.--*Analyses of top bench of coal No. 6 compared with those of the bed excluding the top bench*

(a = top bench; b = sample excluding top bench)

Lab. No.	Co-op. No.	County	Parts of coal bed	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Unit coal B.t.u.
5007	51	Franklin	a	7.67	36.00	50.32	6.01	3.04	14505
			b	10.63	33.23	48.79	7.35	1.40	14534
4813	52	Franklin	a	5.30	39.49	43.88	11.33	5.61	14623
			b	6.96	38.42	44.16	10.46	2.98	14568
4809	52	Franklin	a	6.02	39.85	44.37	9.76	4.12	14710
			b	7.34	38.11	44.23	10.32	3.26	14561
4788	53	Franklin	a	13.97	33.08	49.35	3.60	0.45	14518
			b	10.15	32.88	50.56	6.41	0.59	14494
4783	53	Franklin	a	8.03	33.99	54.93	3.05	0.77	14445
			b	10.00	32.08	50.93	6.98	0.47	14492
4762	54	Perry	a	11.09	33.87	51.92	3.12	0.90	14381
			b	10.32	34.03	46.19	9.46	1.07	14380
4770	54	Perry	a	10.72	33.93	48.48	6.87	2.02	14363
			b	10.05	33.24	45.85	10.86	0.93	14424
4781	55	Perry	a	6.41	38.16	47.17	8.26	3.99	14611
			b	7.17	36.36	45.25	11.22	3.92	14617
4771	55	Jackson	a	9.61	33.91	51.96	4.52	0.57	14417
			b	10.88	31.91	48.90	8.51	0.65	14531
4772	55	Jackson	a	9.86	34.12	52.78	3.24	0.74	14488
			b	10.88	31.71	48.90	8.51	0.65	14531
5210	56	Franklin	a	7.57	38.53	46.84	7.06	2.69	14585
			b	7.71	35.75	45.38	11.16	3.50	14644
4792	58	Franklin	a	7.88	35.46	49.93	6.73	1.83	14564
			b	8.70	34.62	48.92	7.70	0.62	14426
5171	64	Williamson	a	5.93	38.64	47.75	7.68	3.10	14757
			b	7.38	35.59	47.56	9.47	0.86	14617
5003	65	Williamson	a	7.40	37.12	48.96	6.52	3.63	14771
			b	8.58	33.95	48.31	9.16	3.10	14644
5051	85	Clinton	a	12.41	40.40	38.13	9.06	3.91	14364
			b	12.43	37.23	39.93	10.41	4.19	14211

It is probable that a good market might be developed for top coal if it were mined separately, but up to the present time no operator has undertaken such a move.

The other item relates to the close agreement of the heat values for the unit coal. It is thus indicated that the general type of organic matter in the top coal is the same and has the same calorific value as that in the main body of coal.

CALORIFIC VALUES FOR UNIT COAL

As may be seen by reference to Tables 26 and 27, the unit-coal values vary from 14,300 to 15,000 B.t.u. per pound of the corrected ash, moisture, and sulphur-free substance. The coals of a given unit value are fairly constant for a given geographical area. This is a matter of very considerable industrial importance since from the unit coal factor may be calculated the commercial heat value of the coal as delivered with known content of moisture, ash, and sulphur. It is highly important, therefore, that the unit-coal values be accurately established. Table 28 has been prepared using arbitrary factors for moisture, ash, and sulphur. The calculation to commercial coal, or coal as delivered, has been made according to the following formula.⁵

$$\text{Commercial B.t.u.} = \text{"Unit" B.t.u.} \times [1.00 - W - (1.08A + 0.55S)] + 5000S$$

in which W=Moisture

A=Ash

S=Sulphur

A good agreement will be found by comparing the heat values thus obtained by calculation with the observed values as indicated by the calorimeter.

It is of further interest in this connection to compare the results obtained in the survey conducted by the Illinois State Geological Survey in 1908 and published in Bulletin No. 16 with the calorimetric results obtained in the present work. The comparison between the two sets of unit values is, therefore, given in Table 24. Upon examination of the last column where the differences in unit heat values are indicated, it is seen that samples from Vermilion County, the locality nearest the laboratory where the heat values were determined, check each other very closely. All other counties for which comparative data were available, with the exception of Macoupin, are lower. By reference to the working dates for the samples from this county, it is found that the heat determinations for a number of the samples were made

⁵Parr, S. W., Purchase and sale of coal under specifications: Ill. State Geol. Survey Bull. 29, p. 42, 1914.

on the second day after cutting out at the seam. Others were determined on the third and fourth day after cutting out. These periods intervening between cutting out of the sample and analysis at the laboratory average less than any of the other samples. However, the average time for the other samples would not be over five days and that time would be less than the time consumed for the samples of 1908. Moreover, the consistent drop in values, especially since it accompanies a decrease in the time interval, would seem to indicate some influence of the same order as that responsible for the deterioration in heat values described in a former paper.⁶ In these previous investigations two influences were found to operate; namely, the loss of volatile hydrocarbons and the increase in weight due to oxidation. Both operate in the same direction and lower the indicated heat value. The alteration in each case is facilitated by fineness of division and here possibly may be found the explanation. The first series of sam-

TABLE 24.—*Comparison of average unit-coal values in B.t.u. in two series of samples*

County	Coal bed	Number of analyses in 1908 series	Average unit coal in 1908 series (tamper used)	Average unit coal in 1912 series (grinder used)	Difference in value referred to 1908 series
Mercer.....	1	..	.....	.....	....
Rock Island...	1	3	14575	14546	- 29
La Salle.....	2	4	14764	14444	-320
Jackson.....	2	5	14871	14818	- 53
Marshall.....	2	3	14856	14796	- 60
Fulton.....	5	9	14638	14416	-222
Peoria.....	5	8	14692	14614	- 78
Sangamon.....	5	17	14502	14415	- 87
Menard.....	5	4	14534	14478	- 56
Macon.....	5	2	14478	14419	- 41
Saline.....	5	9	14992	14794	-198
Clinton.....	6	5	14378	14290	- 88
Marion.....	6	3	14566	14511	- 55
Montgomery...	6	5	14548	14290	-258
Perry.....	6	9	14501	14407	- 94
St. Clair.....	6	12	14550	14457	- 93
Madison.....	6	8	14407	14370	- 37
Macoupin.....	6	8	14302	14349	+47
Vermilion.....	6	3	14542	14575	+33
Franklin.....	6	7	14621	14538	- 83
Williamson....	6	9	14739	14655	- 84
Vermilion.....	7	2	14754	14740	- 14

⁶Parr, S. W., and Wheeler, W. F., An initial coal substance having a constant thermal value; Ill. State Geol. Survey Bull. 8, p. 166, 1907; also, Weathering of coal; University of Illinois Engineering Experiment Station Bull. 38, 1909.

ples was prepared for shipment by breaking down to about $\frac{1}{2}$ -inch to $\frac{1}{4}$ -inch size. The latter samples were put through a mill which ground to about $\frac{1}{8}$ -inch size. Notwithstanding this drop in values, it is to be noted that all but four of the comparisons check within a difference averaging from 50 to 75 units. No explanation is evident for the four counties which show differences of from 200 to 300 units. The character of the coal, its avidity for oxygen, its greater content of occluded or imprisoned hydrocarbons may be the cause, but direct proof is not at present available. It may also involve the type of iron sulphide present, the size and accessibility of such sulphur compounds, which would favor the formation of iron sulphate as already described in this paper. In any event the unit values for the two series do not vary on the average more than one-half of 1 per cent, and in industrial application the values are doubtless much more closely comparable where the commercial sample is prepared similarly to the second series by grinding to $\frac{1}{8}$ -inch mesh.

TABLE 25.—*Alphabetical arrangement of samples by counties*

County	Coal bed	District	County	Coal bed	District
Bond.....	6	VII	McDonough.....	1, 2	III
Brown.....	1, 2	III	McLean.....	2, 5	I, IV
Bureau.....	2	I	Menard.....	5	IV
Calhoun.....	1, 2	III	Mercer.....	1, 2	III
Christian.....	1, 2, 6	III, VII	Montgomery.....	6	VII
Clinton.....	6	VII	Moultrie.....	6	VII
Edgar.....	6	VIII	Peoria.....	5	IV
Franklin.....	6	VI	Perry.....	6	VI, VII
Fulton.....	1, 2, 5	III, IV	Putnam.....	2	I
Gallatin.....	5, 6	V	Randolph.....	6	VII
Greene.....	1, 2	III	Rock Island.....	1, 2	III
Grundy.....	2	I	St. Clair.....	6	VII
Hancock.....	1, 2	III	Saline.....	5	V
Henry.....	1, 2, 6	III, VII	Sangamon.....	5, 6	IV, VII
Jackson.....	2, 6	II, VI	Schuyler.....	1, 2	III
Jefferson.....	6	VI	Scott.....	1, 2	III
Jersey.....	1, 2	III	Shelby.....	6	VII
Knox.....	1, 2, 5	III, IV	Stark.....	6	I
La Salle.....	2, 5, 7	I	Tazewell.....	5	IV
Livingston.....	2, 5, 7	I	Vermilion.....	6, 7	VIII
Logan.....	5	IV	Warren.....	1, 2	III
Macon.....	5	IV	Washington.....	6	VII
Macoupin.....	6	VII	Woodford.....	2	I
Madison.....	6	VII	Will.....	2	I
Marion.....	6	VII	Williamson.....	6	VI
Marshall.....	2, 6	I			

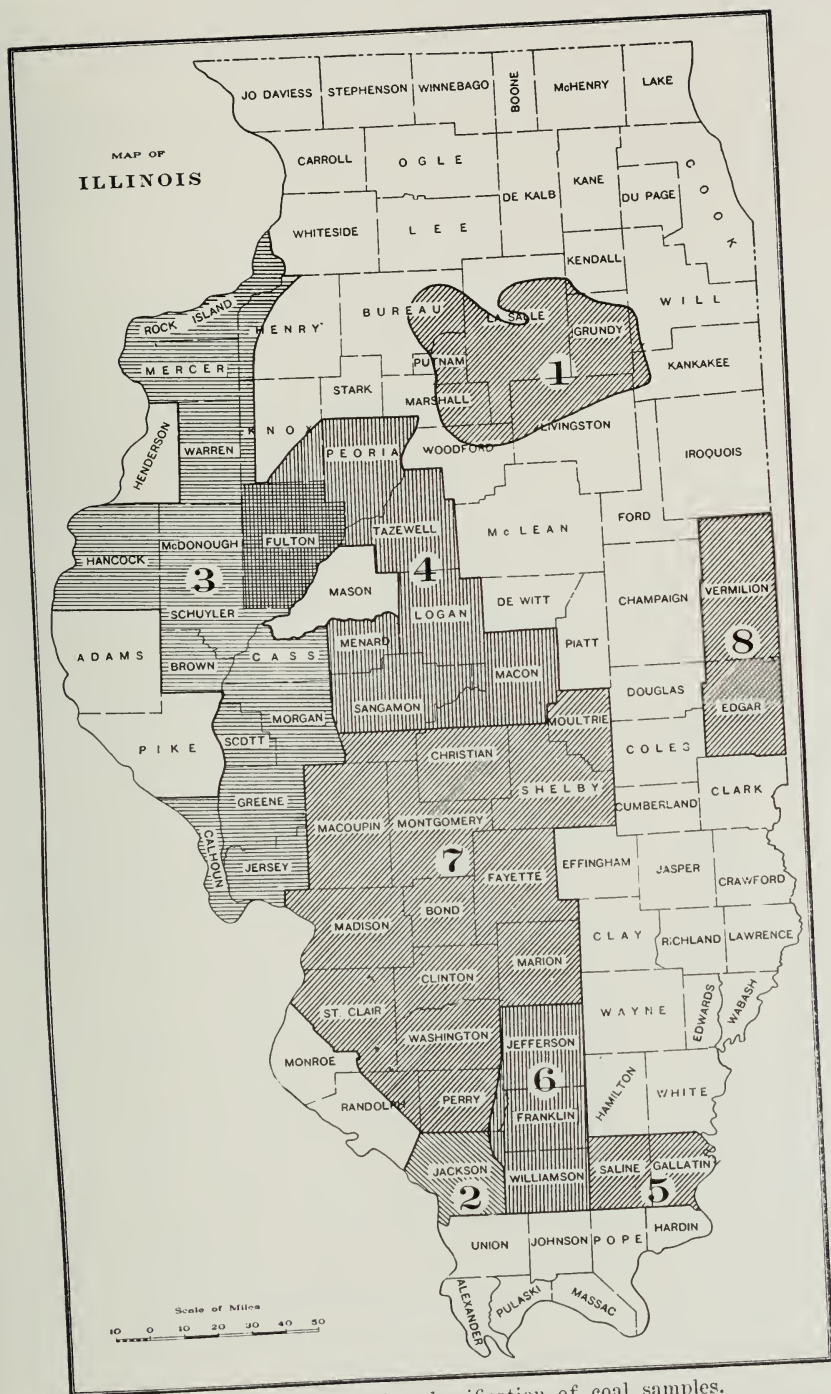


FIG. 10.—Districts for classification of coal samples.

ANALYTICAL TABLES

ANALYSES OF MINE SAMPLES

In Table 26 are given analyses from 345 coal-bed samples which were taken from 100 mines in the State. They are grouped by coal beds and counties and represent all of the producing areas of the State. Table 25 showing counties and district classification is presented for cross reference (fig. 10).

For a given geological bed the counties represented are arranged alphabetically in Table 26. A further grouping is shown by use of the cooperative numbers, these represent samples from the same mine. Two sets of values are given for each sample—one showing the normal or coal-bed moisture, and the other calculated to the dry-coal or moisture-free basis. There is also given the value of the unit-coal in British thermal units as derived by means of the formula already presented.

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd.," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
Coal No. 1												
5229	21	7/12	Christian	1	11.27 Dry	38.68 43.59	40.55 45.70	9.50 10.71	2.07 2.33	.33 .37	11445 12898	14666
5230	21	7/12	Christian	1	11.52 Dry	38.78 43.83	41.01 46.35	8.69 9.82	2.42 2.73	.97 1.10	11648 13163	14707
5231	21	7/12	Christian	1	11.13 Dry	39.21 44.12	41.26 46.43	8.40 9.45	2.56 2.88	.61 .69	11715 13183	14779
5338	19	8/12	Mercer	1	13.23 Dry	40.29 46.43	37.20 42.88	9.28 10.69	4.37 5.04	.41 .47	11104 12797	14641
5339	19	8/12	Mercer	1	15.24 Dry	37.66 44.44	35.73 42.15	11.37 13.41	4.80 5.66	1.47 1.73	10353 12214	14478
5340	19	8/12	Mercer	1	15.15 Dry	39.06 44.44	38.48 42.15	7.31 14.41	3.30 5.66	.17 1.73	11252 12214	14478
5363	19	8/12	Mercer	1	14.97 Dry	38.27 46.03	37.07 45.36	9.69 8.61	3.75 3.89	.33 .19	9637 13260	14760
5364	19	8/12	Mercer	1	14.46 Dry	40.42 44.99	35.33 43.61	9.79 11.40	4.23 4.95	.69 .43	10780 12749	14712
5365	19	8/12	Mercer	1	14.07 Dry	39.95 47.24	34.01 41.32	11.97 11.44	4.55 4.94	.78 .59	10525 12603	14551
5359	18	8/12	Mercer	1	14.58 Dry	39.49 46.49	36.82 39.59	9.11 13.92	5.60 5.29	.15 .91	10894 12247	14604
5360	18	8/12	Mercer	1	15.07 Dry	38.14 46.23	37.44 43.09	9.35 10.68	4.85 6.56	.34 .18	10790 12754	14642
5361	18	8/12	Mercer	1	14.10 Dry	39.60 44.91	36.73 44.01	9.57 11.02	3.92 5.71	.23 .38	10956 12705	14618
5371	17	8/12	Mercer	1	17.75 Dry	39.50 48.03	34.61 42.08	8.14 9.89	5.53 6.72	.86 1.05	10435 12687	14373
5372	17	8/12	Mercer	1	17.50 Dry	38.78 47.00	33.66 40.80	10.06 12.20	4.51 5.46	.29 .35	10238 12409	14372
Coal No. 2												
5324	10	8/12	Bureau	2	16.65 Dry	36.66 43.99	38.58 46.29	8.11 9.72	3.40 4.07	.67 .80	10740 12884	14533
5325	10	8/12	Bureau	2	15.08 Dry	40.12 47.25	36.35 42.80	8.45 9.95	3.68 4.33	.91 1.07	10831 12754	14431
5326	10	8/12	Bureau	2	16.83 Dry	36.54 43.93	39.19 47.12	7.44 8.95	2.64 3.17	.89 1.07	10788 12970	14463
5312	10	8/12	Bureau	2	14.88 Dry	38.69 45.45	37.25 43.76	9.08 10.79	3.83 4.50	1.07 1.25	10685 12553	14357
5313	10	8/12	Bureau	2	17.43 Dry	38.07 46.10	39.44 47.76	5.06 6.14	2.68 3.25	.52 .63	11070 13407	14462
5314	10	8/12	Bureau	2	16.07 Dry	39.68 47.28	38.36 45.71	5.89 7.01	2.96 3.53	.57 .63	11216 13363	14571
5348	8	8/12	Bureau	2	15.19 Dry	39.67 46.78	38.69 45.60	6.45 7.62	2.20 2.62	.99 1.17	11206 13213	14480

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5349	8	8/12	Bureau.....	2	17.34 Dry	37.12 44.90	39.28 47.52	6.26 7.58	2.80 3.38	.49 .59	11006 13314	 14612
5350	8	8/12	Bureau.....	2	16.97 Dry	38.66 46.56	34.83 41.95	9.54 11.49	2.25 2.71	2.29 2.91	10397 12522	 14386
5205	21	7/12	Christian.....	2	12.07 Dry	39.36 44.77	41.91 47.66	6.66 7.57	3.74 4.26	.07 .09	11776 13393	 14730
5206	21	7/12	Christian.....	2	12.53 Dry	38.00 44.12	40.62 46.44	8.25 9.44	3.67 4.22	.31 .35	11389 13020	 14641
5207	21	7/12	Christian.....	2	14.30 Dry	39.54 46.14	40.30 47.02	5.86 6.84	2.00 2.33	.24 .28	11609 13544	 14702
5367	6	8/12	Grundy.....	2	19.97 Dry	38.16 47.68	37.45 46.79	4.42 5.53	1.82 2.27	.65 .79	10936 13664	 14603
5368	6	8/12	Grundy.....	2	18.95 Dry	37.60 46.39	38.23 47.16	5.22 6.45	2.46 3.04	.64 .79	10787 13309	 14400
5369	6	8/12	Grundy.....	2	19.66 Dry	37.01 46.06	38.16 47.50	5.17 6.44	2.03 2.53	.83 1.03	10734 13360	 14337
5373	5	8/12	Grundy.....	2	17.29 Dry	38.61 46.68	36.69 44.36	7.41 8.96	2.87 3.47	1.44 1.74	10708 12947	 14447
5374	5	8/12	Grundy.....	2	13.73 Dry	39.87 46.22	42.19 48.90	4.21 4.88	2.04 2.37	1.47 1.71	11787 13662	 14466
5377	5	8/12	Grundy.....	2	17.01 Dry	39.48 47.57	36.74 44.27	6.77 8.16	3.32 4.00	1.05 1.27	10834 13055	 14446
5375	7	8/12	Grundy.....	2	16.84 Dry	38.37 46.13	41.19 49.53	3.60 4.34	1.74 2.09	.04 .05	11508 13838	 14583
5376	7	8/12	Grundy.....	2	15.81 Dry	39.28 45.48	39.77 47.24	6.13 7.28	2.30 2.73	.24 .28	11212 13318	 14545
5378	7	8/12	Grundy.....	2	16.23 Dry	38.71 46.22	40.61 48.47	4.45 5.31	2.47 2.94	.32 .38	11461 13683	 14610
5225	14	7/12	Jackson.....	2	7.72 Dry	35.09 38.02	48.56 52.62	8.63 9.36	2.01 2.18	.29 .31	12248 13272	 14839
5226	14	7/12	Jackson.....	2	8.77 Dry	32.78 35.93	50.58 55.44	7.87 8.63	2.00 2.19	.02 .03	12253 13430	 14885
5228	14	7/12	Jackson.....	2	9.18 Dry	34.70 38.20	51.58 56.80	4.54 5.00	.60 .66	.05 .06	12752 14040	 14867
5248	13	7/12	Jackson.....	2	9.88 Dry	33.23 36.87	52.43 58.18	4.46 4.95	.70 .77	.33 .36	12709 14103	 14926
5249	13	7/12	Jackson.....	2	10.91 Dry	33.51 37.61	51.26 57.47	4.38 4.92	1.14 1.28	.20 .23	12503 14034	 14863
5250	13	7/12	Jackson.....	2	9.76 Dry	33.45 37.06	52.07 57.71	4.72 5.23	1.08 1.20	.51 .56	12629 13996	 14874
5351	12	7/12	Jackson.....	2	9.51 Dry	33.13 36.62	52.12 57.59	5.24 5.79	.66 .73	.94 1.03	12500 13814	 14758
5252	12	7/12	Jackson.....	2	9.37 Dry	33.39 36.48	49.29 54.38	7.95 8.78	2.11 2.32	.94 1.03	11972 13208	 14671

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5253	12	7/12	Jackson.....	2	9.99 Dry 36.12	32.51 57.63	51.88 57.63	5.62 6.25	.62 .69	.20 .22	12308 13673	 14686
5496	16	8/12	Jackson.....	2	9.25 Dry 38.20	34.67 55.83	50.53 55.83	5.55 6.12	1.41 1.56	.13 .14	12528 13804	 14834
5497	16	8/12	Jackson.....	2	9.56 Dry 38.16	34.52 55.83	50.47 55.83	5.45 6.01	1.32 1.46	.27 .30	12483 13781	 14811
5498	16	8/12	Jackson.....	2	9.20 Dry 37.97	34.48 55.66	50.54 55.66	5.78 6.37	1.44 1.59	.19 .21	12481 13746	 14814
5286	15	8/12	Jackson.....	2	8.32 Dry 38.49	35.28 55.74	51.10 55.74	5.30 5.77	1.39 1.53	.19 .21	12671 13822	 14791
5287	15	8/12	Jackson.....	2	8.86 Dry 38.40	35.00 54.57	49.74 54.57	6.40 7.03	1.69 1.85	.07 .08	12436 13645	 14830
5288	15	8/12	Jackson.....	2	8.91 Dry 37.36	34.03 58.37	53.17 58.37	3.89 4.27	1.15 1.26	.07 .08	12844 14101	 14823
5388	2	8/12	La Salle.....	2	14.22 Dry 46.03	39.49 43.06	36.94 43.06	9.35 10.91	4.46 5.20	.80 .93	10887 12691	 14562
5389	2	8/12	La Salle.....	2	15.16 Dry 47.32	40.13 44.88	38.16 44.88	6.61 7.80	2.99 3.51	.64 .70	11147 13138	 14458
5390	2	8/12	La Salle.....	2	14.43 Dry 46.75	40.01 41.94	35.89 41.94	9.67 11.31	4.47 5.23	1.03 1.21	10678 12476	 14404
5357	4	....	Marshall.....	2	16.46 Dry 46.06	38.48 45.80	38.27 45.80	6.79 8.14	2.91 3.48	.28 .34	11162 13360	 14764
5356	4	....	Marshall.....	2	16.79 Dry 44.23	36.81 48.49	40.34 48.49	6.06 7.28	2.59 3.11	.41 .49	11130 13375	 14620
5358	4	....	Marshall.....	2	17.54 Dry 45.37	37.42 48.62	40.11 48.62	4.93 6.00	2.19 2.56	.42 .50	11273 13669	 14703
5412	11	8/12	Marshall.....	2	12.92 Dry 47.87	41.69 43.19	37.66 43.19	7.78 8.94	2.38 2.73	.64 .73	11597 13319	 14836
5413	11	8/12	Marshall.....	2	13.10 Dry 44.56	38.73 45.61	39.64 45.61	8.53 9.83	3.47 3.99	.65 .75	11414 13134	 14832
5414	11	8/12	Marshall.....	2	13.82 Dry 47.97	41.34 41.64	35.88 41.64	8.96 10.39	3.28 3.81	.50 .59	11296 13106	 14901
5232	22	7/12	McDonough...	2	19.35 Dry 39.35	31.70 50.40	40.61 50.40	8.34 10.35	2.31 2.87	.37 .46	10392 12898	 14605
5233	22	7/12	McDonough...	2	16.46 Dry 40.63	33.94 50.83	42.46 50.83	7.14 8.54	1.71 2.04	.11 .14	11064 13246	 14660
5234	22	7/12	McDonough...	2	16.39 Dry 40.97	34.26 49.47	41.36 49.47	7.99 9.56	2.04 2.44	.33 .40	10977 13130	 14725
5426	100	8/12	McLean.....	2	10.13 Dry 50.07	45.00 39.97	35.92 39.97	8.95 9.96	3.27 3.59	.74 .82	11710 13029	 14723
5427	100	8/12	McLean.....	2	11.34 Dry 45.17	40.05 44.19	39.18 44.19	9.43 10.64	3.18 3.58	.90 1.01	11394 12851	 14643
5428	100	8/12	McLean.....	2	10.61 Dry 46.84	41.87 40.21	35.94 40.21	11.58 12.95	3.79 4.24	.92 1.03	11225 12557	 14752

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal				Sulphur	CO ₂	B. t. u.	Unit coal
					1st: "As recd.," with total moisture. 2nd: "Dry" or moisture free.							
					Moisture	Volatile matter	Fixed carbon	Ash				
5429	100	8/12	McLean.....	2	12.31 Dry	42.17 48.09	38.03 43.37	7.49 8.54	2.69 3.07	.94 1.07	11636 13270	 14722
5430	100	8/12	McLean.....	2	12.00 Dry	42.00 47.73	37.96 43.14	8.04 9.13	2.37 2.70	1.23 1.40	11634 13220	 14759
5433	100	8/12	McLean.....	2	11.27 Dry	42.17 47.53	39.27 44.25	7.29 8.22	2.91 3.28	1.12 1.26	11784 13279	 14684
Coal No. 5												
5283	31	8/12	Fulton.....	5	15.18 Dry	37.17 43.82	35.17 41.45	12.48 14.73	3.45 4.07	1.70 2.00	10201 12026	 14441
5284	31	8/12	Fulton.....	5	16.94 Dry	35.68 42.95	37.15 44.73	10.23 12.32	2.98 3.59	1.31 1.57	10314 12418	 14446
5285	31	8/12	Fulton.....	5	18.42 Dry	34.98 42.88	37.66 46.15	8.94 10.97	2.33 2.85	.86 1.06	10270 12587	 14371
5296	31	8/12	Fulton.....	5	16.82 Dry	37.28 44.81	33.45 40.23	12.45 14.96	2.84 3.42	1.69 2.02	10580 12038	 14479
5298	31	8/12	Fulton.....	5	16.52 Dry	37.17 44.52	36.54 43.78	9.77 11.70	3.91 4.69	.81 .97	10394 12451	 14409
5341	31	8/12	Fulton.....	5	17.37 Dry	35.71 43.22	37.86 45.82	9.06 10.96	2.34 2.83	1.14 1.38	10420 12610	 14398
5293	29	8/12	Fulton.....	5	17.13 Dry	36.23 43.72	34.44 41.55	12.20 14.73	3.03 3.66	1.79 2.16	9846 11882	 14252
5297	29	8/12	Fulton.....	5	16.59 Dry	35.98 43.14	37.20 44.61	10.23 12.25	4.07 4.88	1.77 2.12	10271 12314	 14354
5300	29	8/12	Fulton.....	5	15.41 Dry	35.67 42.16	39.04 46.15	9.88 11.69	3.31 3.92	.52 .61	10579 12505	 14443
5292	28	8/12	Fulton.....	5	17.39 Dry	37.00 44.79	35.69 43.20	9.92 12.01	2.74 3.28	1.14 1.36	10273 12435	 14416
5295	28	8/12	Fulton.....	5	16.33 Dry	36.27 43.34	36.58 43.72	10.82 12.94	3.40 4.06	1.94 2.32	10246 12247	 14371
5299	28	8/12	Fulton.....	5	16.33 Dry	36.75 43.92	38.02 45.44	8.90 10.64	2.59 3.10	1.02 1.22	10604 12674	 14421
5342	32	8/12	Fulton.....	5	13.66 Dry	38.46 44.54	37.06 42.92	10.82 12.54	3.64 4.22	1.26 1.46	10689 12379	 14462
5343	32	8/12	Fulton.....	5	14.53 Dry	37.46 43.83	38.35 44.87	9.66 11.30	3.18 3.72	1.60 1.87	10804 12641	 14525
5344	32	8/12	Fulton.....	5	15.80 Dry	35.84 42.56	37.67 44.74	10.69 12.70	3.00 3.57	1.79 2.12	10460 12423	 14520
5345	30	8/12	Fulton.....	5	16.36 Dry	33.91 40.54	38.19 45.66	11.54 13.80	2.93 3.50	1.27 1.51	10186 12179	 14431
5346	30	8/12	Fulton.....	5	16.33 Dry	35.50 42.42	37.01 44.23	11.16 13.35	2.89 3.45	1.84 2.20	10220 12213	 14389
5347	30	8/12	Fulton.....	5	15.85 Dry	36.12 42.92	38.12 45.30	9.91 11.78	3.36 4.00	1.47 1.75	10494 12471	 14386

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatiles matter	Fixed carbon	Ash				
5025	47	6/12	Gallatin.....	5	5.37 Dry	36.54 38.62	45.10 47.65	12.99 13.73	3.99 4.22	1.38 1.45	11883 12558	 14900
5029	47	6/12	Gallatin.....	5	5.57 Dry	35.49 37.59	48.53 51.39	10.41 11.02	3.12 3.31	.78 .83	12338 13066	 14953
5032	47	6/12	Gallatin.....	5	6.21 Dry	35.29 37.61	46.49 49.57	12.02 12.82	3.30 3.52	.87 .93	11938 12728	 14903
5492	a	8/12	Gallatin.....	5	4.20 Dry	34.41 35.92	52.63 54.92	8.76 9.16	2.85 2.97	.01 .01	12997 13566	 15164
5493	a	8/12	Gallatin.....	5	4.07 Dry	33.99 35.43	52.96 55.21	8.98 9.36	3.61 3.76	.03 .03	12975 13526	 15186
5512	a	8/12	Gallatin.....	5	3.68 Dry	37.82 39.26	48.18 50.02	10.32 10.72	4.55 4.73	.04 .04	12818 13307	 15078
5521	a	8/12	Gallatin.....	5	3.94 Dry	38.13 39.70	45.95 47.82	11.98 12.48	3.53 3.67	.03 .03	12449 12958	 15117
5522	a	8/12	Gallatin.....	b	7.15 Dry	34.34 36.99	53.32 57.42	5.19 5.59	.84 .90	.03 .03	13035 14038	 14970
5523	a	8/12	Gallatin.....	b	4.73 Dry	33.91 35.59	48.65 52.12	11.71 12.29	4.78 5.02	.04 .04	12429 13045	 15240
5530	a	8/12	Gallatin.....	b	4.03 Dry	33.71 35.13	51.84 54.01	10.41 10.86	4.19 4.37	.02 .02	12783 13319	 15256
5391	c	8/12	La Salle.....	5	15.52 Dry	41.56 49.18	32.57 38.55	10.35 12.27	4.08 4.83	.27 .34	10425 12400	 14384
5392	c	8/12	La Salle.....	5	14.13 Dry	39.42 45.90	35.96 41.89	10.49 12.21	3.22 3.75	.96 1.12	10636 12387	 14393
5393	c	8/12	La Salle.....	5	14.64 Dry	43.01 50.38	34.25 40.12	8.10 9.50	2.83 3.32	.56 .66	10961 12841	 14415
5263	33	8/12	Logan.....	5	14.64 Dry	37.87 44.36	35.56 41.66	11.93 13.98	3.60 4.22	1.10 1.28	10400 12183	 14497
5264	33	8/12	Logan.....	5	13.98 Dry	36.86 42.84	37.98 44.16	11.18 13.00	3.14 3.65	1.43 1.67	10549 12264	 14391
5265	33	8/12	Logan.....	5	13.99 Dry	36.85 42.85	38.17 44.37	10.99 12.78	3.26 3.79	1.32 1.53	10519 12230	 14313
5200	42	7/12	Macon.....	5	13.52 Dry	36.72 42.46	39.66 45.86	10.10 11.68	4.23 4.95	.09 .11	10646 12443	 14405
5201	42	7/12	Macon.....	5	13.62 Dry	37.72 43.68	40.34 46.70	8.32 9.62	3.39 3.93	.00 .00	11046 12.88	 14403
5202	42	7/12	Macon.....	5	14.36 Dry	38.06 43.88	39.35 45.37	9.33 10.75	3.87 4.46	.19 .22	10963 12638	 14447
5244	41	7/12	Macon.....	5	14.76 Dry	35.46 41.60	38.08 44.67	11.70 13.73	3.24 3.81	.90 1.06	10390 12189	 14443

*From country banks not in the original list of 100 mines.

bFrom the "Tee House" coal of Kentucky reports.

cFrom a mine not in the original list of 100.

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5245	41	7/12	Macon.....	5	14.54 Dry	36.33 42.51	38.01 44.47	11.12 13.01	3.47 4.06	.68 .79	10465 12244	 14385
5346	41	7/12	Macon.....	5	14.14 Dry	36.21 42.18	38.07 44.34	11.58 13.48	3.24 3.77	1.12 1.31	10493 12210	 14433
5190	34	8/12	Menard....	5	16.29 Dry	36.66 43.80	38.73 46.26	8.32 9.94	3.65 4.36	.59 .71	10747 12838	 14528
5191	34	7/12	Menard.....	5	15.44 Dry	36.38 43.03	39.71 46.96	8.47 10.01	3.34 3.95	.26 .31	10841 12820	 14505
5192	34	7/12	Menard.....	5	20.27 Dry	34.58 43.37	37.43 46.94	7.72 9.69	3.31 4.16	.63 .79	9919 12441	 14402
5431	100	8/12	McLean....	5	12.88 Dry	38.84 44.58	35.80 41.09	12.48 14.33	3.60 4.14	1.17 1.35	10601 12168	 14544
5432	100	8/12	McLean.....	5	13.34 Dry	38.39 44.30	36.72 42.37	11.55 13.33	3.59 4.14	1.31 1.51	10743 12397	 14629
5434	100	8/12	McLean.....	5	13.73 Dry	36.79 42.64	36.14 41.89	13.34 15.47	3.99 4.62	1.19 1.30	10399 12054	 14639
5303	26	8/12	Peoria.....	5	16.00 Dry	36.06 42.93	37.54 44.69	10.40 12.38	2.90 3.46	1.27 1.51	10515 12518	 14773
5304	26	8/12	Peoria.....	5	14.23 Dry	37.41 43.62	37.36 43.56	11.00 12.82	3.14 3.66	2.17 2.53	10573 12327	 14433
5305	26	8/12	Peoria.....	5	14.76 Dry	35.95 42.18	35.34 41.46	13.95 16.36	3.19 3.74	2.00 2.34	10173 11935	 14636
4985	43	6/12	Saline.....	5	6.34 Dry	37.72 40.27	48.20 51.46	7.74 8.27	2.03 2.16	.61 .65	12620 13474	 14869
4986	43	6/12	Saline.....	5	6.40 Dry	37.11 39.65	49.59 52.97	6.90 7.38	2.27 2.43	.40 .43	12678 13546	 14800
4987	43	6/12	Saline.....	5	8.85 Dry	32.53 35.65	51.52 56.57	7.10 7.78	.92 1.00	.66 .72	12321 13502	 14774
4989	43	6/12	Saline.....	5	6.80 Dry	35.06 37.61	50.39 54.07	7.75 8.32	2.30 2.46	.03 .03	12514 13428	 14853
4990	43	6/12	Saline.....	5	6.02 Dry	38.23 40.68	47.53 50.58	8.22 8.74	2.67 2.84	.45 .48	12538 13341	 14831
4992	43	6/12	Saline.....	5	7.39 Dry	35.38 38.20	50.73 54.78	6.50 7.02	2.15 2.32	.01 .01	12642 13650	 14848
4991	44	6/12	Saline.....	5	6.49 Dry	35.85 38.34	50.46 53.97	7.20 7.69	2.82 3.02	.01 .01	12634 13511	 14841
4993	44	6/12	Saline.....	5	6.71 Dry	35.68 38.24	49.64 53.21	7.97 8.55	2.69 2.88	.00 .00	12482 13379	 14839
4994	44	6/12	Saline.....	5	6.90 Dry	34.42 36.97	48.55 52.16	10.13 10.87	2.16 2.32	.03 .03	12088 12984	 14793
4997	45	6/12	Saline.....	5	6.71 Dry	35.59 38.14	49.98 53.59	7.72 8.27	2.38 2.55	.14 .16	12092 13332	 14725
4999	45	6/12	Saline.....	5	7.45 Dry	34.18 36.94	49.88 53.90	8.49 9.16	2.78 3.01	.01 .01	12336 13329	 14901

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5001	45	6/12	Saline.....	5	6.94 Dry	34.56 37.14	50.93 54.72	7.57 8.14	2.30 2.46	.16 .18	12485 13415	 14792
4995	48	6/12	Saline.....	5	7.57 Dry	34.36 37.18	48.30 52.25	9.77 10.57	2.42 2.62	1.75 1.89	11956 12934	 14692
5002	48	6/12	Saline.....	5	7.45 Dry	33.71 36.42	51.27 55.40	7.57 8.18	2.63 2.84	.31 .35	12400 13398	 14794
5010	48	6/12	Saline.....	5	7.99 Dry	33.63 36.55	51.20 55.65	7.18 7.80	2.61 2.84	.05 .05	12346 13419	 14732
5012	49	6/12	Saline.....	5	5.19 Dry	38.37 40.47	45.92 48.43	10.52 11.10	4.06 4.28	.46 .49	12260 12932	 14847
5015	49	6/12	Saline.....	5	5.52 Dry	36.89 39.04	45.89 48.58	11.70 12.38	4.97 5.26	.72 .76	11962 12662	 14809
5016	49	6/12	Saline.....	5	4.90 Dry	38.93 40.94	45.90 48.26	10.27 10.80	4.77 5.01	.47 .49	12355 12991	 14815
5019	46	6/12	Saline.....	5	8.08 Dry	35.26 38.35	48.25 52.50	8.41 9.15	2.60 2.83	.38 .41	12192 13263	 14818
5020	46	6/12	Saline.....	5	7.70 Dry	35.48 38.44	48.66 52.72	8.16 8.84	2.52 2.74	.32 .36	12304 13331	 14833
5021	46	6/12	Saline.....	5	8.25 Dry	34.98 38.12	47.73 52.03	9.04 9.85	2.40 2.61	.85 .92	11964 13040	 14684
5022	46	6/12	Saline.....	5	7.72 Dry	34.09 36.94	49.22 53.34	8.97 9.72	3.31 3.58	.23 .25	12050 13057	 14716
5023	46	6/12	Saline.....	5	8.14 Dry	34.60 37.66	48.10 52.36	9.16 9.98	2.42 2.64	.74 .80	11989 13051	 14717
5024	46	6/12	Saline.....	5	7.85 Dry	33.72 36.59	49.30 53.50	9.13 9.91	3.48 3.78	.25 .26	11971 12990	 14676
5118	36	7/12	Sangamon....	5	16.05 Dry	35.82 42.66	37.14 44.25	10.99 13.09	3.55 4.22	.67 .80	10330 12306	 14476
5119	36	7/12	Sangamon....	5	15.53 Dry	36.36 43.04	38.05 45.05	10.06 11.91	3.86 4.57	.55 .66	10522 12457	 14450
5120	36	7/12	Sangamon....	5	14.45 Dry	37.46 43.79	38.27 44.73	9.82 11.48	3.59 4.19	.55 .65	10704 12512	 14423
5128	37	7/12	Sangamon....	5	14.08 Dry	37.38 43.51	37.56 43.71	10.98 12.78	3.97 5.17	.38 .49	9471 12337	 14492
5129	37	7/12	Sangamon....	5	13.86 Dry	37.11 43.08	39.05 45.34	9.98 11.58	2.57 4.07	.52 .61	10726 12451	 14365
5166	39	7/12	Sangamon....	5	13.38 Dry	37.20 42.95	36.40 42.03	13.01 15.02	4.78 5.52	.96 1.10	10338 11934	 14439
5167	39	7/12	Sangamon....	5	13.37 Dry	36.64 42.27	37.12 42.85	12.89 14.88	4.80 5.53	.84 .97	10348 11942	 14423
5168	39	7/12	Sangamon....	5	13.19 Dry	38.44 44.28	36.47 42.00	11.90 13.72	4.61 5.31	1.05 1.20	10513 12110	 14397
5187	40	7/12	Sangamon....	5	14.82 Dry	37.18 43.65	38.22 44.87	9.78 11.48	4.30 4.52	.72 .84	10683 12541	 14483

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5188	40	7/12	Sangamon...	5	16.05 Dry	35.58 42.38	38.04 45.32	10.33 12.30	4.18 4.98	.17 .20	10413 12404	 14476
5189	40	7/12	Sangamon...	5	14.31 Dry	37.31 43.54	38.20 44.58	10.18 11.88	4.21 4.91	.90 1.05	10655 12434	 14251
5196	38	7/12	Sangamon...	5	14.25 Dry	37.25 43.44	37.07 43.24	11.43 13.32	4.76 5.55	.98 1.15	10414 12147	 14381
5197	38	7/12	Sangamon...	5	14.10 Dry	38.74 45.09	37.66 43.85	9.50 11.06	3.86 4.50	.75 .87	10790 12564	 14415
5198	38	7/12	Sangamon...	5	14.44 Dry	38.22 44.67	37.68 44.04	9.66 11.29	3.79 4.43	.63 .73	10746 12549	 14435
5199	38	7/12	Sangamon...	5	14.08 Dry	38.05 44.28	35.30 41.09	12.57 14.63	5.87 6.83	.60 .69	10228 11903	 14366
5289	25	8/12	Sangamon...	5	14.23 Dry	36.65 42.73	37.04 43.18	12.08 14.09	3.39 3.96	1.55 1.81	10483 12220	 14553
5290	25	8/12	Sangamon...	5	14.54 Dry	37.41 43.77	37.32 43.67	10.73 12.56	3.27 3.82	1.18 1.38	10705 12526	 14625
5291	25	8/12	Sangamon...	5	16.00 Dry	36.46 43.41	37.28 44.38	10.26 12.21	3.65 4.35	.90 1.07	10583 12598	 14664
5277	27	7/12	Tazewell....	5	14.71 Dry	37.46 44.06	38.57 44.03	10.26 11.91	3.51 4.07	1.15 1.33	10801 12516	 14500
5278	27	7/12	Tazewell....	5	13.88 Dry	37.58 43.64	40.01 46.45	8.53 9.91	2.55 2.96	.95 1.10	11076 12860	 14499
5281	27	8/12	Tazewell....	5	15.56 Dry	37.60 44.53	36.70 43.46	10.14 12.01	3.23 3.83	1.50 1.78	10552 12496	 14488
Coal No. 6												
5052	85	8/12	Clinton.....	6	12.60 Dry	36.78 42.07	40.48 46.32	10.14 11.61	2.88 3.29	.77 .88	10827 12388	 14269
5053	85	7/12	Clinton.....	6	12.15 Dry	37.74 42.96	40.52 46.13	9.59 10.91	3.51 3.99	.29 .33	10949 12464	 14256
5054	85	7/12	Clinton.....	6	12.43 Dry	37.23 41.28	39.93 46.84	10.41 11.88	4.19 4.79	.38 .44	10730 12253	 14211
5073	84	7/12	Clinton.....	6	13.32 Dry	37.43 43.18	39.02 45.02	10.23 11.80	4.06 4.68	.69 .80	10726 12374	 14336
5074	84	7/12	Clinton.....	6	12.40 Dry	37.94 43.32	39.04 44.56	10.62 12.12	4.24 4.84	.58 .69	10796 12323	 14380
4785	53	4/12	Franklin....	6	10.57 Dry	33.37 37.30	43.09 48.19	12.97 14.51	.83 .93	4.38 4.89	10714 11980	 14236
4786	53	4/12	Franklin....	6	10.00 Dry	32.80 36.45	50.92 56.59	6.27 6.96	.66 .73	.33 .36	12001 13334	 14453
4787	53	4/12	Franklin....	6	10.15 Dry	32.88 36.58	50.56 56.27	6.41 7.14	.59 .65	.22 .25	12000 13356	 14494
4789	53	4/12	Franklin....	6	10.00 Dry	32.08 35.65	50.93 56.60	6.98 7.75	.47 .52	.17 .20	11935 13261	 14492
4791	58	4/12	Franklin....	6	8.70 Dry	34.62 37.92	48.92 53.59	7.76 8.49	.62 .68	.31 .34	11945 13084	 14426

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
4793	58	4/12	Franklin. . . .	6	9.04 Dry	34.46 37.88	48.73 53.59	7.77 8.53	.68 .74	.23 .25	11946 13133	 14490
4794	58	4/12	Franklin.	6	9.05 Dry	34.45 37.88	48.75 53.59	7.75 8.53	.91 1.00	.37 .41	11923 13108	 14472
4810	52	4/12	Franklin.	6	6.96 Dry	38.42 41.29	44.16 47.47	10.46 11.24	2.98 3.21	.92 .99	11848 12733	 14568
4811	52	4/12	Franklin.	6	7.34 Dry	38.11 41.13	44.23 47.73	10.32 11.14	3.26 3.51	1.41 1.53	11771 12703	 14561
4812	52	4/12	Franklin.	6	6.00 Dry	38.55 41.01	45.46 48.36	9.99 10.63	3.16 3.36	1.20 1.28	11998 12776	 14534
5008	51	6/12	Franklin.	6	10.63 Dry	33.23 37.18	48.79 54.59	7.35 8.23	1.40 1.19	.38 .43	11800 13207	 14534
5009	51	6/12	Franklin.	6	9.83 Dry	33.91 37.62	49.14 54.48	7.12 7.90	1.13 1.25	.18 .20	11942 13245	 14522
5011	51	6/12	Franklin.	6	10.39 Dry	33.13 36.97	49.23 54.93	7.25 8.10	1.37 1.53	.06 .06	11920 13303	 14629
5208	56	7/12	Franklin.	6	6.43 Dry	37.62 40.20	44.77 47.85	11.18 11.95	2.64 2.82	.64 .68	11834 12646	 14620
5209	56	7/12	Franklin.	6	10.15 Dry	35.55 39.56	45.82 51.01	8.48 9.43	1.41 1.57	.80 .89	11691 13011	 14539
5211	56	7/12	Franklin.	6	7.71 Dry	35.75 38.74	45.38 49.17	11.16 12.09	3.50 3.79	.89 .96	11644 12616	 14644
5222	50	7/12	Franklin.	6	9.66 Dry	34.55 38.24	47.85 52.97	7.95 8.79	1.04 1.15	.31 .34	11916 13190	 14613
5223	50	7/12	Franklin.	6	9.00 Dry	35.10 38.58	47.35 53.03	8.55 9.39	1.08 1.19	.40 .44	11973 13159	 14684
5224	50	7/12	Franklin.	6	9.36 Dry	34.86 38.46	48.90 53.96	6.88 7.58	1.01 1.12	.43 .48	12122 13373	 14603
5507	57	8/12	Franklin.	6	9.83 Dry	31.82 35.28	49.78 55.22	8.57 9.50	.79 .88	.35 .39	11702 12977	 14490
5508	57	8/12	Franklin.	6	9.44 Dry	32.57 35.97	50.09 55.31	7.90 8.72	.67 .74	.29 .32	11914 13156	 14547
5509	57	8/12	Franklin.	6	9.75 Dry	32.33 35.83	48.77 54.03	9.15 10.14	1.39 1.54	.32 .35	11652 12911	 14550
5528	d	8/12	Gallatin.	6	10.82 Dry	33.83 37.94	42.43 47.57	12.92 14.49	4.93 5.53	.42 .47	11263 11609	 15193
4773	55	4/12	Jackson.	6	10.88 Dry	31.71 35.57	48.90 54.88	8.51 9.55	.65 .73	.30 .34	11594 13009	 14531
4780	55	4/12	Jackson.	6	7.17 Dry	36.36 39.18	45.25 48.74	11.22 12.08	3.92 4.22	.43 .47	11678 12581	 14617
4784	55	4/12	Jackson.	6	8.82 Dry	35.30 38.72	44.96 49.30	10.92 11.98	3.46 3.79	.50 .54	11547 12663	 14676

*From country bank not included in list of 100 mines.

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5086	66	7/12	Macoupin....	6	4.29 Dry	39.09 45.60	37.21 43.42	9.41 10.98	4.13 4.82	.32 .37	10635 12408	 14234
5087	66	7/12	Macoupin....	6	13.77 Dry	38.69 44.86	36.74 42.62	10.80 12.52	4.37 5.07	.62 .71	10493 12169	 14236
5088	66	7/12	Macoupin....	6	14.73 Dry	38.33 44.95	37.24 43.69	9.70 11.36	4.50 5.28	.30 .35	10522 12339	 14237
5097	69	7/12	Macoupin....	6	14.73 Dry	36.26 42.53	36.11 42.34	12.90 15.13	4.62 5.42	.28 .33	10099 11843	 14342
5098	69	7/12	Macoupin....	6	13.68 Dry	38.02 44.05	37.72 43.70	10.58 12.25	4.43 5.12	.21 .25	10618 12300	 14346
5099	69	7/12	Macoupin....	6	14.19 Dry	37.92 44.19	37.03 43.15	10.86 12.66	4.21 4.91	.39 .45	10599 12351	 14476
5100	67	7/12	Macoupin....	6	15.12 Dry	38.28 45.09	36.55 43.06	10.05 11.85	3.85 4.54	.31 .37	10610 12501	 14488
5101	67	7/12	Macoupin....	6	14.90 Dry	37.75 44.35	38.43 45.16	8.92 10.49	3.67 4.31	.45 .53	10735 12614	 14367
5102	67	7/12	Macoupin....	6	14.67 Dry	35.49 41.59	38.83 45.50	11.01 12.91	4.15 4.86	.22 .26	10433 12227	 14370
5112	68	7/12	Macoupin....	6	12.11 Dry	40.32 45.88	39.14 44.52	8.43 9.60	4.39 5.00	.38 .43	11170 12705	 14335
5113	68	7/12	Macoupin....	6	13.27 Dry	38.58 44.48	38.15 43.99	10.00 11.53	4.89 5.64	.27 .31	10790 12442	 14400
5114	68	7/12	Macoupin....	6	13.23 Dry	38.85 44.77	38.91 44.84	9.01 10.39	4.39 5.06	.28 .32	10935 12601	 14359
5067	72	7/12	Madison.....	6	13.08 Dry	38.03 43.75	37.07 42.65	11.82 13.60	5.22 6.01	.25 .28	10543 12129	 14423
5068	72	7/12	Madison.....	6	13.53 Dry	37.26 43.84	40.98 45.53	8.23 10.63	3.81 4.37	.30 .23	10903 12587	 14363
5069	72	7/12	Madison.....	6	14.86 Dry	37.32 43.84	38.76 45.53	9.06 10.63	3.73 4.37	.20 .23	10717 12587	 14363
5070	71	7/12	Madison.....	6	12.99 Dry	37.73 43.36	36.89 42.40	12.39 14.24	4.43 5.09	.72 .82	10499 12066	 14440
5071	71	7/12	Madison.....	6	12.14 Dry	41.13 46.82	38.00 43.24	8.73 9.94	3.52 4.00	.41 .47	11206 12759	 14426
5072	71	7/12	Madison.....	6	12.42 Dry	39.82 45.46	37.65 43.00	10.11 11.54	4.35 4.96	.72 .80	10909 12456	 14398
5075	73	7/12	Madison.....	6	14.65 Dry	39.08 45.80	38.03 44.55	8.24 9.65	3.59 4.20	.29 .34	10865 12730	 14347
5076	73	7/12	Madison.....	6	14.31 Dry	38.35 44.75	38.32 44.72	9.02 10.53	3.77 4.40	.31 .37	10739 12532	 14283
5078	73	7/12	Madison.....	6	15.18 Dry	38.40 45.27	38.30 45.16	8.12 9.57	3.94 4.64	.23 .27	10751 12673	 14284
5515	70	8/12	Madison.....	6	13.88 Dry	37.60 43.65	37.74 43.82	10.78 12.53	4.21 4.89	.53 .61	10551 12250	 14330

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5517	70	8/12	Madison.....	6	12.44 Dry	39.10 44.65	38.20 43.64	10.26 11.71	5.23 6.03	.64 .73	10818 12354	 14343
5518	70	8/12	Madison.....	6	12.11 Dry	39.32 44.74	36.27 41.26	12.30 14.00	4.92 5.60	.47 .53	10615 12076	 14421
5030	86	6/12	Marion.....	6	12.45 Dry	37.22 42.03	39.81 44.96	11.52 13.01	3.62 4.09	.67 .76	10874 12281	 14426
5033	86	6/12	Marion.....	6	10.24 Dry	39.06 43.51	39.79 44.33	10.91 12.16	4.18 4.65	.30 .34	11180 12456	 14499
5035	86	6/12	Marion.....	6	10.69 Dry	38.76 43.41	39.01 43.66	11.54 12.93	3.98 4.47	.51 .57	10963 12275	 14418
5039	87	6/12	Marion.....	6	10.06 Dry	37.96 42.21	41.09 45.69	10.89 12.10	3.92 4.35	.59 .66	11289 12555	 14589
5041	87	6/12	Marion.....	6	10.35 Dry	36.04 40.20	42.81 47.75	10.80 12.05	4.10 4.57	.25 .28	11227 12522	 14551
5044	87	6/12	Marion.....	6	10.96 Dry	36.54 41.04	40.68 45.69	11.82 13.27	4.00 4.52	.43 .48	11002 12364	 14583
5105	76	7/12	Montgomery..	6	14.15 Dry	36.96 43.05	38.19 44.48	10.70 12.47	3.43 4.00	.91 1.06	10547 12285	 14329
5106	76	7/12	Montgomery..	6	13.83 Dry	36.95 42.88	39.22 45.51	10.00 11.61	3.72 4.32	.91 1.05	10728 12455	 14382
5107	76	7/12	Montgomery..	6	13.70 Dry	37.25 43.17	37.93 43.94	11.12 12.89	4.39 5.08	1.04 1.20	10444 12102	 14225
5516	77	8/12	Montgomery..	6	14.00 Dry	36.88 42.88	40.02 46.54	9.10 10.58	3.84 4.47	.48 .57	10761 12511	 14268
5254	e	8/12	Moultrie.....	6	7.07 Dry	39.02 41.09	43.01 46.28	10.90 11.73	3.69 3.97	.36 .39	11912 12819	 14736
5255	e	8/12	Moultrie.....	6	7.18 Dry	38.09 41.03	41.38 44.59	13.35 14.38	5.18 5.58	.46 .49	11573 12468	 14973
5256	e	8/12	Moultrie.....	6	6.24 Dry	40.34 43.03	42.55 45.38	10.87 11.59	3.18 3.39	.89 .95	12149 12957	 14937
4756	54	3/12	Perry.....	6	10.32 Dry	34.03 37.94	46.19 51.51	9.46 10.55	1.07 1.18	.24 .26	11395 12705	 14380
4759	54	3/12	Perry.....	6	10.41 Dry	33.43 37.32	47.12 52.59	9.04 10.09	.88 .98	.23 .25	11486 12822	 14367
4760	54	3/12	Perry.....	6	10.22 Dry	33.32 37.11	46.75 52.07	9.71 10.82	1.04 1.15	.23 .25	11270 12553	 14383
4764	54	3/12	Perry.....	6	9.98 Dry	33.71 37.45	44.91 49.88	11.40 12.67	.84 .93	.33 .37	11205 12447	 14452
4766	54	3/12	Perry.....	6	9.64 Dry	33.49 37.06	45.60 50.47	11.27 12.47	.82 .90	.35 .39	11230 12428	 14394
4768	54	3/12	Perry.....	6	10.05 Dry	33.24 36.94	45.85 50.98	10.86 12.08	.93 1.04	.63 .70	11257 12513	 14424

*From a mine not included in the list of 100.

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd." with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5034	90	6/12	Perry.....	6	10.60 Dry	37.03 41.42	42.32 47.35	10.05 11.23	3.73 4.17	.62 .70	11175 12500	 14365
5037	90	6/12	Perry.....	6	11.20 Dry	37.29 42.00	40.57 45.69	10.94 12.31	3.20 3.60	.34 .39	10911 12287	 14288
5038	90	6/12	Perry.....	6	10.60 Dry	35.99 40.25	43.05 48.16	10.36 11.59	4.18 4.67	.47 .53	11012 12317	 14228
5040	90	6/12	Perry.....	6	11.60 Dry	37.03 41.89	42.17 47.71	9.20 10.40	3.84 4.34	.38 .43	11107 12570	 14301
5042	90	6/12	Perry.....	6	10.82 Dry	37.83 42.42	41.52 46.56	9.83 11.02	2.98 3.34	.76 .85	11210 12570	 14380
5043	90	6/12	Perry.....	6	10.89 Dry	36.81 41.29	41.23 46.27	11.07 12.44	3.71 4.16	.55 .52	10826 12277	 14319
5048	88	7/12	Perry.....	6	9.37 Dry	36.87 40.68	41.05 45.29	12.71 14.02	4.62 4.83	.43 .47	10936 12067	 14395
5049	88	7/12	Perry.....	6	9.34 Dry	37.97 41.88	41.32 45.58	11.37 12.54	3.16 3.48	1.42 1.56	11099 12243	 14276
5050	88	7/12	Perry.....	6	10.11 Dry	36.44 40.54	41.45 40.12	12.00 13.34	3.59 3.99	.75 .81	10915 12141	 14321
5514	89	8/12	Perry.....	6	12.45 Dry	35.55 40.59	42.86 48.94	9.16 10.47	4.80 5.48	.21 .25	11063 12632	 14422
5519	89	8/12	Perry.....	6	12.76 Dry	35.18 41.79	44.32 49.34	7.74 8.87	1.66 1.90	.15 .17	11357 13018	 14458
5520	89	8/12	Perry.....	6	12.17 Dry	36.42 41.46	42.41 48.28	9.00 10.26	1.96 2.23	.46 .52	11200 12753	 14414
5045	83	8/12	Randolph....	6	11.38 Dry	36.94 41.68	40.25 45.41	11.43 12.91	4.16 4.69	.72 .81	10823 12212	 14348
5046	83	8/12	Randolph....	6	10.62 Dry	38.10 42.63	39.12 43.77	12.16 13.60	4.45 4.98	.42 .47	10849 12137	 14400
5047	83	8/12	Randolph....	6	11.39 Dry	36.80 41.53	41.04 46.32	10.77 12.15	4.11 4.63	.60 .67	10895 12294	 14306
5115	75	8/12	Sangamon...	6	14.97 Dry	36.90 43.39	38.36 45.12	9.77 11.49	3.53 4.16	.59 .67	10598 12466	 14361
5116	75	8/12	Sangamon...	6	14.51 Dry	37.60 43.98	39.69 46.43	8.20 9.59	3.44 4.02	.22 .25	10911 12763	 14373
5117	75	8/12	Sangamon...	6	12.98 Dry	38.23 43.94	38.92 44.72	9.87 11.34	4.32 4.96	.56 .65	10845 12463	 14368
5130	74	7/12	Sangamon...	6	15.22 Dry	38.23 45.09	37.36 44.07	9.19 10.84	4.38 5.17	.38 .45	10579 12478	 14301
5131	74	7/12	Sangamon...	6	13.10 Dry	38.86 44.72	37.25 42.86	10.79 12.42	5.08 5.86	.41 .47	10592 12387	 14268
5132	74	7/12	Sangamon...	6	14.43 Dry	38.14 44.58	37.07 43.32	10.36 12.10	4.77 5.58	.40 .47	10495 12265	 14292
5056	79	7/12	St. Clair....	6	10.69 Dry	40.16 44.97	37.87 42.39	11.28 12.64	4.55 5.10	.58 .65	11063 12387	 14522

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5058	79	7/12	St. Clair....	6	12.12 Dry	38.61 43.93	40.61 46.22	8.66 9.85	3.10 3.52	.35 .39	11217 12764	 14399
5059	79	7/12	St. Clair....	6	11.12 Dry	40.54 45.61	38.27 43.06	10.07 11.33	4.18 4.70	.32 .36	11145 12540	 14483
5055	78	7/12	St. Clair....	6	13.06 Dry	38.21 43.95	37.36 42.96	11.37 13.09	3.21 3.70	1.17 1.35	10741 12354	 14515
5060	78	7/12	St. Clair....	6	11.44 Dry	38.73 43.73	38.11 43.04	11.72 13.23	4.26 4.81	.56 .64	10841 12242	 14447
5061	78	7/12	St. Clair....	6	10.75 Dry	39.19 43.91	38.88 43.56	11.18 12.53	3.41 3.82	.67 .75	11041 12371	 14438
5077	81	7/12	St. Clair....	6	11.35 Dry	39.68 44.75	38.59 43.54	10.38 11.71	4.05 4.57	.58 .65	11036 12449	 14404
5079	81	7/12	St. Clair....	6	10.85 Dry	40.75 45.71	38.36 43.03	10.04 11.26	4.09 4.58	.58 .65	11192 12554	 14445
5080	81	7/12	St. Clair....	6	11.50 Dry	40.68 45.96	37.91 42.84	9.91 11.20	3.96 4.47	.46 .52	10908 12597	 14482
5108	82	7/12	St. Clair....	6	10.99 Dry	38.96 43.77	58.79 43.59	11.26 12.64	4.36 4.90	.36 .40	11047 12411	 14544
5109	82	7/12	St. Clair....	6	13.42 Dry	39.23 45.31	36.92 42.65	10.43 12.04	4.92 5.69	.26 .31	10753 12419	 14474
5110	82	7/12	St. Clair....	6	11.40 Dry	40.96 46.23	36.89 41.63	10.75 12.14	4.10 4.63	.57 .63	11052 12472	 14511
5524	80	7/12	St. Clair....	6	10.11 Dry	39.72 44.19	38.87 43.24	11.30 12.57	3.69 4.10	.78 .86	11051 12294	 14361
5525	80	8/12	St. Clair....	6	9.83 Dry	39.84 44.19	37.97 42.11	12.36 13.70	4.02 4.45	.87 .96	10958 12152	 14415
5526	80	8/12	St. Clair....	6	10.19 Dry	38.44 42.79	40.41 45.00	10.96 12.21	3.95 4.49	.68 .78	11127 12388	 14418
4670	93	2/12	Vermilion...	6	13.68 Dry	36.28 42.03	41.37 47.92	8.67 10.05	2.78 3.23	.45 .52	11101 12861	 14537
4671	93	2/12	Vermilion...	6	15.50 Dry	33.32 39.43	43.11 51.03	8.07 9.54	1.86 2.20	.46 .62	10976 12989	 14558
4674	93	2/12	Vermilion...	6	15.69 Dry	34.52 40.95	42.22 50.07	7.57 8.98	1.56 1.85	.53 .63	11019 13085	 14553
4676	93	2/12	Vermilion...	6	14.56 Dry	35.04 41.01	41.82 48.95	8.58 10.04	2.09 2.45	.74 .86	11006 12881	 14527
4678	93	2/12	Vermilion...	6	16.06 Dry	34.67 41.32	40.75 48.53	8.52 10.15	1.79 2.14	.90 1.07	10810 12879	 14537
4679	93	2/12	Vermilion...	6	15.95 Dry	34.66 41.23	42.06 50.05	7.33 8.72	1.41 1.68	.39 .46	11041 13136	 14557
4702	92	3/12	Vermilion...	6	15.53 Dry	33.60 39.78	39.46 46.70	11.41 13.52	2.32 2.75	.98 1.15	10404 12317	 14520
4703	92	3/12	Vermilion...	6	15.70 Dry	32.38 38.81	39.80 47.72	11.36 13.47	2.57 3.04	1.06 1.26	10392 12328	 14535

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Continued.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
4704	92	3/12	Vermilion...	6	15.27 Dry	33.98 40.10	40.88 48.24	9.87 11.66	2.26 2.66	.69 .81	10718 12649	 14563
4706	95	3/12	Vermilion...	6	11.87 Dry	40.37 45.80	39.52 44.86	8.24 9.34	3.07 3.48	.74 .84	11416 12953	 14525
4707	95	3/12	Vermilion...	6	13.14 Dry	38.81 44.69	38.11 43.87	9.94 11.44	4.18 4.82	.88 1.02	10949 12604	 14549
4740	91	6/12	Vermilion...	6	13.58 Dry	35.20 40.73	39.83 46.09	11.39 13.18	3.19 3.69	.83 .96	10821 12521	 14733
4741	91	6/12	Vermilion...	6	13.63 Dry	34.56 40.01	41.19 47.69	10.62 12.30	2.91 3.36	.78 .90	10954 12683	 14747
4742	91	6/12	Vermilion...	6	14.50 Dry	35.98 42.09	40.49 47.35	9.03 10.56	2.43 2.83	.44 .52	11090 12971	 14740
4743	91	6/12	Vermilion...	6	14.20 Dry	35.79 41.71	42.05 49.01	7.96 9.28	1.83 2.13	.34 .39	11295 13165	 14703
4744	91	6/12	Vermilion...	6	13.99 Dry	35.26 40.99	42.68 49.63	8.07 9.38	1.67 1.94	.98 1.14	11271 13104	 14706
4745	91	6/12	Vermilion...	6	14.79 Dry	34.44 40.42	42.69 50.10	8.08 9.48	1.72 2.02	.98 1.15	11053 12971	 14519
4746	91	6/12	Vermilion...	6	15.14 Dry	33.70 39.72	40.19 47.34	10.97 12.94	2.50 2.95	.61 .72	10663 12565	 14712
4998	65	6/12	Williamson...	6	9.35 Dry	32.83 36.21	50.07 55.24	7.75 8.55	1.05 1.16	.26 .29	12017 13256	 14644
5004	65	6/12	Williamson...	6	9.95 Dry	33.79 37.53	48.56 53.96	7.66 8.51	.99 1.10	.06 .06	11899 13218	 14593
5005	65	6/12	Williamson...	6	8.58 Dry	33.95 37.14	48.31 52.84	9.16 10.02	3.10 3.39	.14 .16	11845 12956	 14644
4996	60	6/12	Williamson...	6	8.32 Dry	34.61 37.75	47.56 51.88	9.51 10.37	2.25 2.46	.24 .26	11978 13066	 14801
5000	60	6/12	Williamson...	6	7.55 Dry	34.90 37.74	47.37 51.23	10.20 11.03	3.23 3.49	.60 .65	11799 12760	 14607
5006	60	6/12	Williamson...	6	8.81 Dry	32.13 35.62	51.85 56.38	7.21 8.00	1.00 1.11	.13 .16	11962 13264	 14572
5121	61	6/12	Williamson...	6	9.44 Dry	33.63 37.13	49.58 54.75	7.35 8.12	1.28 1.42	.19 .21	12092 13354	 14685
5133	61	7/12	Williamson...	6	8.99 Dry	34.22 37.62	49.51 54.39	7.28 7.99	1.70 1.87	.04 .04	12149 13349	 14674
5134	61	7/12	Williamson...	6	9.38 Dry	33.62 37.10	50.01 55.18	6.99 7.72	1.12 1.24	.14 .16	12138 13394	 14654
5122	59	7/12	Williamson...	6	9.79 Dry	33.28 36.89	48.66 53.94	8.27 9.17	1.32 1.46	.44 .49	11891 13181	 14681
5123	59	7/12	Williamson...	6	10.67 Dry	32.54 36.42	47.32 52.97	9.47 10.61	1.53 1.71	.15 .17	11619 13006	 14748
5124	59	7/12	Williamson...	6	10.96 Dry	33.14 37.24	45.86 51.49	10.04 11.27	1.72 1.93	.55 .62	11383 12784	 14624

TABLE 26.—*Analyses of mine samples (not exactly indicative of commercial output)*
—Concluded.

Lab. No.	Co-op. No.	Date 1912	County	Coal bed	Proximate analysis of coal 1st: "As recd," with total moisture. 2nd: "Dry" or moisture free.				Sulphur	CO ₂	B. t. u.	Unit coal
					Moisture	Volatile matter	Fixed carbon	Ash				
5125	62	7/12	Williamson..	6	9.97 Dry	32.20 35.76	49.62 55.12	8.21 9.12	1.47 1.63	.22 .25	11814 13123	 14610
5126	62	7/12	Williamson..	6	8.37 Dry	34.19 37.31	50.18 54.77	7.26 7.92	1.03 1.12	.18 20	12254 13374	 14663
5127	62	7/12	Williamson..	6	9.06 Dry	32.93 36.20	49.98 54.97	8.03 8.83	1.03 1.13	24 27	12010 13207	 14637
5170	64	7/12	Williamson..	6	11.51 Dry	30.75 34.76	49.74 56.20	8.00 9.04	.84 .90	.32 .36	11554 13057	 14501
5169	64	7/12	Williamson..	6	9.13 Dry	32.03 35.25	51.06 56.20	7.77 8.55	1.10 1.21	.33 .36	12044 13254	 14613
5172	64	7/12	Williamson..	6	7.38 Dry	35.59 38.42	47.56 51.35	9.47 10.23	.86 .93	.51 .55	12017 12974	 14617
5180	63	7/12	Williamson..	6	10.38 Dry	32.76 36.56	48.10 53.67	8.76 9.77	1.50 1.67	.16 .18	11735 13072	 14672
5181	63	7/12	Williamson..	6	8.78 Dry	34.25 37.54	47.56 52.14	9.41 10.32	2.49 2.73	.53 .58	11885 13029	 14758
5182	63	7/12	Williamson..	6	9.26 Dry	33.36 36.76	48.70 53.68	8.68 9.56	1.83 2.01	.39 .43	11955 13176	 14761
Coal No. 7												
5416	99	8/12	La Salle.....	7	13.82 Dry	41.42 48.06	35.90 41.67	8.86 10.27	3.95 4.58	.51 .59	11174 12966	 14744
5414	99	8/12	La Salle.....	7	12.87 Dry	42.40 48.67	37.35 42.86	7.88 8.47	3.86 4.44	.00 .00	11468 13161	 14635
5417	99	8/12	La Salle.....	7	13.99 Dry	38.81 45.12	40.12 46.65	7.08 8.23	3.23 3.76	.00 .00	11401 13255	 14675
4711	94	3/12	Vermilion...	7	12.20 Dry	39.53 45.03	38.38 43.70	9.89 11.27	3.76 4.29	.46 .52	11243 12804	 14730
4713	94	3/12	Vermilion...	7	12.70 Dry	39.20 44.90	39.24 44.95	8.86 10.15	2.79 3.19	.52 .59	11399 13057	 14776
4714	94	3/12	Vermilion...	7	12.76 Dry	38.84 44.53	38.31 43.91	10.09 11.56	3.91 4.48	.61 .70	11106 12788	 14773
4716	94	3/12	Vermilion...	7	12.67 Dry	39.01 44.67	37.43 42.86	10.89 12.47	3.54 4.06	.84 .96	11041 12644	 14734
4722	94	3/12	Vermilion...	7	13.53 Dry	37.39 43.24	39.57 45.76	9.51 11.00	3.20 3.70	.46 .54	11045 12773	 14622
4724	94	3/12	Vermilion...	7	13.27 Dry	37.25 42.95	40.65 46.87	8.83 10.18	3.27 3.77	.38 .44	11209 12925	 14650
4727	97	3/12	Vermilion...	7	12.92 Dry	36.98 42.46	38.94 44.73	11.16 12.81	2.90 3.33	.70 .80	10924 12544	 14715
4734	97	3/12	Vermilion...	7	13.10 Dry	38.42 44.22	39.14 45.03	9.34 10.75	2.26 2.59	.56 .64	11281 12981	 14778
4736	97	3/12	Vermilion...	7	13.41 Dry	37.33 43.11	38.87 44.89	10.39 12.00	2.54 2.93	.46 .53	11065 12778	 14787

AVERAGE ANALYSIS BY MINES AND BY COUNTIES

In Table 27, the average of all the values for each mine is given and these values for each county are assembled for more convenient reference. Further, since as a rule, the variations for "unit" values in a county are slight, the average for the county is calculated from the several mine averages. These values are therefore accurate for the various counties named, though, of course, the range of variation for each mine would be less than for the county as a whole.

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.

DISTRICT NO. 1.—BUREAU CO., COAL NO. 2, LONGWALL MINING

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	"Unit coal"
1	16.19 Dry	37.79 45.06	38.06 45.40	8.00 9.54	3.24 3.86	.82 .98	10787 12869	14476
8	16.50 Dry	38.48 46.08	37.59 45.02	7.43 8.90	2.40 2.90	1.16 1.39	10868 13016	14493
10	16.13 Dry	38.82 46.28	38.36 45.74	6.69 7.98	3.15 3.76	.70 .84	10994 13108	14463
Average	16.27 Dry	38.35 45.80	38.00 45.39	7.38 8.81	2.93 3.50	.89 1.40	10883 12997	14477

DISTRICT NO. 1.—GRUNDY CO., COAL NO. 2, LONGWALL MINING

5	16.01 Dry	39.32 46.83	38.51 45.84	6.16 7.33	2.75 3.28	1.32 1.57	11104 13221	14463
6	19.53 Dry	37.59 46.71	37.94 47.15	4.94 6.14	2.01 2.61	.70 .87	10818 13444	14447
7	16.29 Dry	38.46 45.94	40.53 48.42	4.72 5.64	2.17 2.59	.48 .57	11394 13613	14579
Average	17.28 Dry	38.48 46.49	39.02 47.14	5.27 6.37	2.33 2.82	.83 1.00	11113 13426	14496

DISTRICT NO. 1.—LA SALLE CO., COAL NO. 2, LONGWALL MINING

2	14.60 Dry	39.88 46.70	36.97 43.29	8.55 10.01	3.97 4.65	.81 .95	10904 12768	14475
3	15.05 Dry	39.76 46.80	37.00 43.56	8.19 9.64	3.30 3.88	.59 .69	10899 12830	14454
9	17.45 Dry	38.98 47.22	34.52 41.82	9.04 10.95	3.18 3.85	1.49 1.81	10391 12587	14403
Average	15.70 Dry	39.54 46.91	36.17 42.89	8.59 10.20	3.48 4.12	.96 1.15	10731 12728	14444

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 1.—MARSHALL CO., COAL NO. 2, LONGWALL MINING

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	"Unit coal"
4	16.93	37.57	39.57	5.93	2.53	.37	11188	14696
	Dry	45.22	47.64	7.14	3.05	.44	13468	
11	13.28	40.58	37.71	8.43	3.04	.60	11435	14896
	Dry	46.80	43.48	9.72	3.51	.69	13186	
Average	15.10	39.06	38.68	7.16	2.79	.48	11315	14796
	Dry	46.01	45.56	8.43	3.28	.56	13327	

DISTRICT NO. 2.—JACKSON CO., COAL NO. 2, ROOM-AND-PILLAR MINING

12	9.62	33.02	51.09	6.27	1.13	.69	12260	14705
	Dry	36.53	56.53	6.94	1.25	.76	13565	
13	10.18	33.40	51.90	4.52	.97	.29	12614	14888
	Dry	37.18	57.79	5.03	1.08	.32	14044	
14	8.56	34.18	50.25	7.01	1.54	.09	12418	14864
	Dry	37.39	54.95	7.66	1.68	.10	13581	
15	8.70	34.77	51.34	5.19	1.42	.09	12651	14815
	Dry	38.08	56.23	5.69	1.55	.12	13856	
16	9.34	34.55	50.52	5.59	1.40	.26	12490	14820
	Dry	38.11	55.72	6.17	1.54	.29	13777	
Average	9.28	33.98	51.02	5.72	1.29	.29	12488	14818
	Dry	37.46	56.24	6.30	1.42	.32	13765	

DISTRICT NO. 3.—CHRISTIAN CO., COAL NO. 1, ROOM-AND-PILLAR MINING

21	11.31	38.89	40.94	8.86	2.35	.43	11602	14717
	Dry	43.85	46.16	9.99	2.65	.48	13081	

DISTRICT NO. 3.—MERCER CO., COAL NO. 1, ROOM-AND-PILLAR MINING

17	17.63	39.13	34.13	9.11	5.02	.70	10336	14373
	Dry	47.51	41.44	11.05	6.09	.85	12548	
18	14.58	39.07	37.00	9.35	4.79	.21	10880	14640
	Dry	45.74	43.31	10.95	5.61	.25	12737	
19	14.52	39.26	36.32	9.90	4.24	.68	10809	14624
	Dry	45.93	42.49	11.58	4.96	.80	12645	
Average	15.58	39.17	35.80	9.45	4.69	.53	10673	14546
	Dry	46.40	42.41	11.19	5.55	.63	12643	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 4.—FULTON CO., COAL NO. 5, CENTRAL ILLINOIS

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
28	16.68	36.68	36.76	9.88	2.90	1.36	10375	14403
	Dry	44.02	44.12	11.86	3.48	1.63	12452	
29	16.38	35.96	36.88	10.78	3.47	1.02	10230	14349
	Dry	43.01	44.10	12.89	4.15	1.22	12234	
30	16.18	35.17	37.77	10.88	3.06	1.53	10296	14402
	Dry	41.96	45.06	12.98	3.65	1.82	12284	
31	16.88	36.32	36.32	10.48	2.98	1.25	10269	14424
	Dry	43.70	43.70	12.61	3.58	1.50	12355	
32	14.66	37.24	37.71	10.39	3.28	1.54	10651	14502
	Dry	43.64	44.18	12.18	3.84	1.81	12481	
Aver- age	16.16	36.27	37.09	10.48	3.14	1.33	10363	14416
	Dry	43.26	44.24	12.50	3.74	1.59	12361	

DISTRICT NO. 4.—LOGAN CO., COAL NO. 5, CENTRAL ILLINOIS

33	14.20	37.19	37.44	11.37	3.34	1.42	10490	14400
	Dry	43.35	43.40	13.25	3.89	1.66	12226	

DISTRICT NO. 4.—MACON CO., COAL NO. 5, CENTRAL ILLINOIS

41	14.48	36.00	38.05	11.47	3.32	.90	10445	14420
	Dry	42.10	44.49	13.41	3.88	1.05	12214	
42	13.83	37.35	39.62	9.20	3.83	.09	10877	14418
	Dry	43.34	45.98	10.68	4.45	.11	12623	
Aver- age	14.15	36.68	38.83	10.34	3.57	.52	10661	14419
	Dry	42.73	45.23	12.04	4.16	.60	12418	

DISTRICT NO. 4.—MENARD CO., COAL NO. 5, CENTRAL ILLINOIS

34	17.33	35.88	38.62	8.17	3.44	.50	10499	14478
	Dry	43.40	46.72	9.88	4.16	.60	12700	

DISTRICT NO. 4.—PEORIA CO., COAL NO. 5, CENTRAL ILLINOIS

25	14.92	36.92	37.21	11.02	3.44	1.21	10951	14614
	Dry	43.30	43.74	12.95	4.04	1.42	12448	
26	15.00	36.48	36.75	11.77	3.08	1.80	10421	14614
	Dry	42.91	43.24	13.85	3.62	2.12	12260	
Aver- age	14.96	36.65	36.99	11.40	3.26	1.50	10506	14614
	Dry	43.10	43.49	13.40	3.83	1.77	12354	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 4.—SANGAMON CO., COAL NO. 5, CENTRAL ILLINOIS

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
36	15.34	36.54	37.83	10.29	3.67	.59	10519	14450
	Dry	43.16	44.68	12.16	4.33	.70	12425	
37	13.78	37.82	37.69	10.73	4.11	.47	10625	14396
	Dry	43.86	43.71	12.44	4.77	.55	12323	
38	14.26	38.07	37.48	10.19	4.14	.37	10649	14410
	Dry	44.40	43.71	11.89	4.83	.43	12420	
39	13.31	37.43	36.66	12.60	4.72	.94	10398	14420
	Dry	43.17	42.29	14.54	5.45	1.09	11995	

DISTRICT NO. 4.—TAZEWELL CO., COAL NO. 5, CENTRAL ILLINOIS

27	14.38	37.74	38.23	9.66	3.10	1.20	10809	14496
	Dry	44.08	44.65	11.28	3.62	1.40	12624	

DISTRICT NO. 5 GALLATIN CO., COAL NO. 5, SOUTHERN ILLINOIS

47	5.72	35.77	46.71	11.80	3.47	1.01	12053	14919
	Dry	37.94	49.54	12.52	3.68	1.07	12784	
Extra	4.13	34.21	52.80	8.86	3.23	.02	12987	15175
	Dry	35.68	55.07	9.25	3.37	.03	13546	
Extra	3.68	37.82	48.18	10.32	4.55	.04	12818	15078
	Dry	39.26	50.02	10.72	4.73	.05	13307	
Extra	3.94	38.13	45.95	11.98	3.53	.03	12449	15117
	Dry	39.70	47.82	12.48	3.67	.04	12958	
Extra	4.03	33.71	51.84	10.42	4.19	.02	12783	15256
	Dry	35.13	54.01	10.86	4.37	.02	13319	
Average	4.30	35.93	49.08	10.69	3.79	.24	12616	15109
	Dry	37.54	51.29	11.17	3.96	.25	13183	

EXTRA SAMPLE GALLATIN CO., COAL NO. 5

	3.72	34.44	52.91	8.93	3.76	.03	13032	15187
	Dry	35.77	54.96	9.27	3.90	.03	13535	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 5. SALINE CO., COAL NO. 5, SOUTHERN ILLINOIS

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
43	6.97	35.98	49.69	7.36	2.05	.32	12550	14829
	Dry	38.68	53.41	7.92	2.20	.34	13490	
44	6.70	35.31	49.55	8.44	2.56	.02	12401	14824
	Dry	37.85	53.11	9.04	2.74	.02	13291	
45	7.03	34.78	50.27	7.92	2.48	.26	12420	14806
	Dry	37.41	54.07	8.52	2.67	.28	13359	
46	7.96	34.68	48.54	8.82	2.79	.46	12077	14741
	Dry	37.68	52.74	9.58	3.03	.50	13122	
48	7.67	33.90	50.26	8.17	2.56	.70	12234	14739
	Dry	36.72	54.43	8.85	2.77	.76	13250	
49	5.20	38.06	45.90	10.84	4.60	.59	12193	14824
	Dry	40.15	48.42	11.43	4.85	.62	12862	
Average	6.92	35.44	49.06	8.58	3.76	.42	12314	14794
	Dry	38.08	52.70	9.22	4.04	.42	13229	

DISTRICT NO. 6.—FRANKLIN CO., COAL NO. 6, EAST OF DUQUOIN ANTICLINE

50	9.34	34.84	48.03	7.79	1.04	.38	12004	14633
	Dry	38.42	52.99	8.59	1.15	.42	13241	
51	10.28	33.42	49.05	7.25	1.18	.10	11890	14562
	Dry	37.26	54.66	8.08	1.32	.11	13252	
52	6.77	38.35	44.62	10.26	3.13	.91	11875	14554
	Dry	41.14	47.85	11.00	3.36	.98	12737	
53	10.18	32.78	48.88	8.16	.64	.61	11661	14419
	Dry	36.50	54.41	9.09	.71	.68	12983	
56	8.10	36.30	45.34	10.26	2.51	.74	11826	14601
	Dry	39.50	49.34	11.16	2.73	.80	12758	
57	9.67	35.69	49.55	8.54	.95	.32	11756	14529
	Dry	32.24	54.86	9.45	1.05	.35	13015	
58	8.93	34.51	48.80	7.76	.74	.36	11937	14463
	Dry	37.89	53.59	8.52	.81	.40	13108	
Average	9.04	34.62	47.78	8.56	1.45	.44	11837	14538
	Dry	38.06	52.53	9.41	1.59	.48	13013	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

EXTRA SAMPLES.—GALLATIN CO., COAL NO. 6

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
	10.82	33.83	42.43	12.92	4.93	.42	11263	15193
	Dry	37.94	47.57	14.94	5.53	.47	12629	
	4.28	36.06	49.06	10.60	3.71	.05	12583	15079
	Dry	37.67	51.25	11.08	3.88	.05	13146	
Aver- age	7.54	34.96	45.68	11.82	4.34	.23	11916	15136
	Dry	37.81	49.41	12.78	4.70	.25	12888	

DISTRICT NO. 6.—JACKSON CO., COAL NO. 6, EAST OF DUQUOIN ANTICLINE

55	8.96	34.44	46.40	10.20	2.65	.40	11609	14608
	Dry	37.83	50.97	11.20	2.91	.44	12751	

DISTRICT NO. 6.—PERRY CO., COAL NO. 6, EAST OF DUQUOIN ANTICLINE

54	9.92	32.72	46.97	10.39	.92	.25	11335	14407
	Dry	36.81	52.15	11.53	1.02	.28	12583	

DISTRICT NO. 6.—WILLIAMSON CO., COAL NO. 6, EAST OF DUQUOIN ANTICLINE

59	10.47	32.99	47.27	9.27	1.52	.38	11630	14684
	Dry	36.85	52.80	10.35	1.70	.43	12990	
60	8.22	34.00	48.79	8.99	2.16	.33	11959	14660
	Dry	37.04	53.16	9.80	2.35	.36	13030	
61	9.27	33.83	49.70	7.20	1.37	.13	12127	14671
	Dry	37.28	54.78	7.94	1.51	.14	13366	
62	9.13	33.09	49.94	7.84	1.17	.22	12028	14637
	Dry	36.42	54.95	8.63	1.29	.24	13236	
63	9.47	33.45	48.13	8.95	1.94	.36	11852	14730
	Dry	36.96	53.16	9.88	2.14	.40	13092	
64	9.34	32.77	49.48	8.41	.92	.52	11872	14577
	Dry	36.15	54.58	9.27	1.01	.57	13095	
65	9.31	33.52	48.98	8.19	1.70	.13	11919	14627
	Dry	36.96	54.01	9.03	1.88	.14	13143	
Aver- age	9.31	33.38	48.90	8.41	1.54	.36	11913	14655
	Dry	36.81	53.92	9.27	1.70	.40	13136	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 7.—CLINTON CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
84	12.86	37.26	39.53	10.35	4.26	.58	10755	14335
	Dry	42.76	45.36	11.88	4.89	.66	12342	
85	12.39	36.88	40.68	10.05	3.52	.72	10836	14245
	Dry	42.10	46.43	11.47	4.02	.82	12368	
Average	12.62	37.08	40.10	10.20	3.90	.66	10796	14290
	Dry	42.43	45.90	11.67	4.46	.75	12355	

DISTRICT NO. 7.—MACOUPIN CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

66	14.26	38.70	37.07	9.97	4.34	.41	10549	14236
	Dry	45.14	43.24	11.62	5.06	.48	12304	
67	14.19	37.48	38.24	9.99	3.92	.33	10558	14408
	Dry	43.68	44.57	11.75	4.57	.39	12447	
68	12.87	39.24	38.73	9.16	4.56	.30	10964	14365
	Dry	45.04	44.45	10.51	5.23	.35	12583	
69	14.20	37.40	36.95	11.45	4.42	.29	10438	14388
	Dry	43.59	43.06	13.35	5.15	.34	12165	
Average	13.88	38.20	37.75	10.17	4.31	.34	10657	14349
	Dry	44.36	43.83	11.81	5.00	.39	12375	

DISTRICT NO. 7.—MADISON CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

70	12.81	38.67	37.40	11.12	4.80	.44	10661	14365
	Dry	44.35	42.91	12.75	5.51	.54	12227	
71	12.52	39.55	37.51	10.42	4.09	.61	10871	14421
	Dry	45.21	42.88	11.91	4.68	.70	12427	
72	13.82	37.54	38.94	9.70	4.25	.25	10722	14391
	Dry	43.56	45.19	11.25	4.93	.29	12441	
73	14.71	38.61	38.22	8.46	3.76	.28	10785	14305
	Dry	45.27	44.81	9.92	4.41	.33	12645	
Average	13.47	38.59	38.03	9.91	4.22	.42	10760	14370
	Dry	44.60	43.95	11.45	4.88	.49	12435	

DISTRICT NO. 7.—MARION CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

86	11.13	38.20	39.39	11.28	3.91	.50	10964	14448
	Dry	42.98	44.32	12.70	4.40	.56	12337	
87	10.46	36.85	41.53	11.16	4.01	.42	11174	14574
	Dry	41.15	46.38	12.47	4.48	.47	12480	
Average	10.79	37.53	40.46	11.22	3.96	.45	11069	14511
	Dry	42.07	45.35	12.58	4.44	.51	12408	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 7.—MONTGOMERY CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
76	13.89	37.05	38.44	10.62	3.85	.94	10574	14312
	Dry	43.04	44.64	12.32	4.47	1.10	12280	
77	14.40	36.70	39.84	9.06	3.83	.49	10709	14268
	Dry	42.88	46.54	10.58	4.47	.57	12511	
Average	14.15	36.88	39.14	9.83	3.84	.70	10642	14290
	Dry	42.96	45.59	11.45	4.47	.83	12396	

DISTRICT NO. 7.—PERRY CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

88	9.61	37.09	41.27	12.03	3.70	.86	10982	14331
	Dry	41.03	45.66	13.30	4.10	.95	12150	
89	12.45	36.14	42.77	8.64	2.80	.27	11207	14431
	Dry	41.28	48.85	9.87	3.20	.31	12801	
90	10.95	37.00	41.82	10.23	3.61	.56	11060	14314
	Dry	41.55	46.96	11.50	4.05	.63	12420	
Average	11.00	36.75	41.97	10.28	3.36	.56	11087	14359
	Dry	41.29	47.16	11.55	3.78	.63	12457	

DISTRICT NO. 7.—RANDOLPH CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

83	11.13	37.28	40.14	11.45	4.24	.58	10855	14351
	Dry	41.95	45.17	12.89	4.77	.65	12214	

DISTRICT NO. 7.—ST. CLAIR CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

78	11.75	38.71	38.12	11.43	3.63	.80	10874	14466
	Dry	43.86	43.19	12.95	4.11	.91	12322	
79	11.31	39.77	38.92	10.00	3.94	.63	11143	14468
	Dry	44.84	43.89	11.27	4.44	.71	12564	
80	10.04	39.33	39.09	11.54	3.91	.78	11045	14398
	Dry	43.72	43.45	12.83	4.35	.87	12278	
81	11.23	40.36	38.31	10.10	4.03	.54	11126	14444
	Dry	45.47	43.17	11.39	4.54	.61	12533	
82	11.94	39.72	37.53	10.81	4.46	.39	10949	14510
	Dry	45.10	42.62	12.27	5.07	.45	12434	
Average	11.25	39.57	38.39	10.79	3.99	.63	11028	14457
	Dry	44.59	43.26	12.15	4.50	.71	12426	

TABLE 27.—Average analytical and heat values for separate mines and by counties
—Grouped according to districts.—Continued.

DISTRICT NO. 7.—SANGAMON CO., COAL NO. 6, WEST OF DUQUOIN ANTICLINE

Co-op. No.	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	CO ₂	B. t. u.	“Unit coal”
74	14.25	38.42	37.22	10.11	4.75	.39	10556	14287
	Dry	44.80	43.42	11.79	5.54	.46	12310	
75	14.15	37.58	38.99	9.28	3.76	.45	10786	14369
	Dry	43.77	45.42	10.81	4.38	.52	12564	
Average	14.20	37.99	38.11	9.70	4.26	.42	10671	14329
	Dry	44.28	44.42	11.30	4.96	.49	12437	

DISTRICT NO. 8.—VERMILION CO., COAL NO. 6, EASTERN ILLINOIS

91	14.44	35.04	40.99	9.53	2.37	.66	10982	14697
	Dry	40.95	47.91	11.14	2.77	.77	12836	
92	15.59	33.47	40.16	10.78	2.33	.89	10508	14536
	Dry	39.65	47.58	12.77	2.76	1.06	12449	
93	15.19	34.95	41.55	8.31	2.04	.65	10961	14533
	Dry	41.21	48.99	9.80	2.41	.77	12925	
95	12.59	40.16	38.53	8.72	3.49	.80	11228	14532
	Dry	45.94	44.08	9.98	3.99	.92	12845	
Average	14.45	35.88	40.33	9.34	2.55	.75	10920	14575
	Dry	41.94	47.14	10.92	2.98	.88	12764	

DISTRICT NO. 8.—VERMILION CO., COAL NO. 7, EASTERN ILLINOIS

94	12.69	38.78	38.89	9.64	3.34	.52	11221	14725
	Dry	44.42	44.54	11.04	3.83	.59	12852	
97	13.18	37.85	38.65	10.32	2.54	.60	11080	14754
	Dry	43.59	44.52	11.89	2.92	.69	12762	
Average	12.99	38.28	38.75	9.98	2.93	.56	11143	14740
	Dry	44.00	44.53	11.47	3.37	.64	12807	

DISTRICT NO. 9.—LA SALLE CO., COAL NO. 7

99	13.56	40.87	37.80	7.77	3.68	.17	11347	14685
	Dry	47.28	43.73	8.99	4.26	.20	13127	

DISTRICT NO. 9.—MCLEAN CO., COAL NO. 5

100	13.32	38.00	36.21	12.47	3.73	1.20	10580	14604
	Dry	43.84	41.78	14.38	4.30	1.39	12206	

DISTRICT NO. 9.—MCLEAN CO., COAL NO. 2

100	11.26	42.21	37.73	8.80	3.03	.98	11566	14714
	Dry	47.57	42.52	9.91	3.41	1.10	13034	

In Table 28 calculations have been made to illustrate the use which can be made of "unit-coal" values in estimating the possible guarantees for bidding and for letting of contracts. A range of values for ash and moisture has been assumed merely for the purpose of illustration.

TABLE 28.—Unit-coal values ranging from 14,300 to 15,000 B. t. u. calculated to the "as-received" basis having normal variations of moisture, ash, and sulphur, as indicated.

Coal beds and general location by counties	Ash	Sulphur	B. t. u. with 10 per cent moisture	B. t. u. with 12 per cent moisture	B. t. u. with 14 per cent moisture
Unit coal—14,300					
Coal No. 6 in Clinton, Macoupin, Madison, Montgomery, Perry, Randolph counties, and Sangamon County south of Auburn.	10	4	11,211	10,925	10,639
	11	4	11,056	10,771	10,484
	12	4	10,902	10,616	10,330
	13	4	10,747	10,462	10,176
	14	4	10,592	10,308	10,021
	15	4	10,437	10,154	9,867
	16	4	10,282	10,000	9,712
	17	4	10,127	9,846	9,558
	18	4	9,972	9,692	9,403
	19	4	9,817	9,538	9,250
	20	4	9,662	9,384	9,094
Unit coal—14,400					
Coal No. 5 in Fulton, Logan, Macon, and Sangamon counties.	10	4	11,288	11,000	10,712
	11	4	11,132	10,844	10,556
	12	4	10,977	10,688	10,401
	13	4	10,821	10,532	10,246
	14	4	10,665	10,376	10,091
Coal No. 5 in La Salle County.	15	4	10,509	10,220	9,936
	16	4	10,353	10,064	9,781
Coal No. 6 in Macoupin, Madison, Randolph, and St. Clair counties.	17	4	10,197	9,908	9,626
	18	4	10,041	9,752	9,471
	19	4	9,885	9,596	9,316
	20	4	9,732	9,440	9,161
Unit coal—14,500					
Coal No. 1 in Mercer County.	10	3	11,394	11,105	10,815
	11	3	11,238	10,948	10,658
	12	3	11,081	10,792	10,501
Coal No. 2 in Bureau, Grundy, and La Salle counties.	13	3	10,925	10,635	10,344
	14	3	10,769	10,478	10,187
	15	3	10,613	10,322	10,030
Coal No. 5 in Menard and Tazewell counties.	16	3	10,456	10,165	9,873
	17	3	10,300	10,008	9,716
Coal No. 6 in Marion and Vermilion counties.	18	3	10,144	9,852	9,559
	19	3	9,987	9,695	9,402
	20	3	9,829	9,539	9,249

TABLE 28.—Unit-coal values ranging from 14,300 to 15,000 B. t. u. calculated to the "as-received" basis having normal variations of moisture, ash, and sulphur, as indicated.—Continued.

Coal beds and general location by counties	Ash	Sulphur	B. t. u. with 10 per cent moisture	B. t. u. with 12 per cent moisture	B. t. u. with 14 per cent moisture
Unit coal—14,600					
Coal No. 5 in McLean and Peoria counties.	10	3	11,472	11,180	10,888
	11	3	11,315	11,023	10,731
	12	3	11,157	10,865	10,572
	13	3	10,999	10,707	10,415
	14	3	10,841	10,549	10,258
Coal No. 6 in Jackson and Vermilion counties.	15	3	10,683	10,392	10,101
	16	3	10,526	10,234	9,944
	17	3	10,368	10,077	9,786
	18	3	10,210	9,919	9,628
	19	3	10,053	9,761	9,471
	20	3	9,896	9,604	9,312
Unit coal—14,600					
Coal No. 2 in McLean County.	10	1	11,533	11,191	10,949
	11	1	11,325	11,083	10,791
	12	1	11,217	10,926	10,633
	13	1	11,060	10,768	10,476
Coal No. 6 in Franklin County east of Duquoin anticline, in Jackson, Perry, and Williamson counties.	14	1	10,903	10,610	10,318
	15	1	10,745	10,453	10,161
	16	1	10,587	10,295	10,003
	17	1	10,430	10,138	9,846
	18	1	10,272	9,980	9,668
	19	1	10,114	9,823	9,531
	20	1	9,957	9,664	9,372
Unit coal—14,700					
Coal No. 2 in Christian County.	10	3	11,550	11,256	10,962
	11	3	11,391	11,097	10,803
	12	3	11,232	10,938	10,644
	13	3	11,073	10,779	10,485
	14	3	10,913	10,620	10,326
Coal No. 7 in La Salle and Vermilion counties.	15	3	10,755	10,461	10,167
	16	3	10,596	10,302	10,008
	17	3	10,437	10,143	9,849
	18	3	10,278	9,984	9,690
	19	3	10,119	9,825	9,531
	20	3	9,960	9,668	9,374
Unit coal—14,800					
Coal No. 2 in Jackson and Marshall counties.	10	3	11,973	11,677	11,331
	11	3	11,813	11,517	11,172
	12	3	11,654	11,358	11,012
	13	3	11,494	11,198	10,852
	14	3	11,335	11,036	10,693
Coal No. 5 in Saline County.	15	3	11,175	10,877	10,533
	16	3	11,016	10,715	10,373
	17	3	10,856	10,555	10,214
	18	3	10,697	10,395	10,054
	19	3	10,537	10,235	9,895
	20	3	10,378	10,075	9,733

TABLE 28.—Unit-coal values ranging from 14,300 to 15,000 B. t. u. calculated to the "as-received" basis having normal variations of moisture, ash, and sulphur, as indicated.—Concluded.

Coal beds and general location by counties	Ash	Sulphur	B. t. u. with 10 per cent moisture	B. t. u. with 12 per cent moisture	B. t. u. with 14 per cent moisture
Unit coal—14,800					
Coal No. 5 in Saline County.	10	2.5	11,940	11,644	11,348
	11	2.5	11,780	11,484	11,188
	12	2.5	11,620	11,324	11,028
	13	2.5	11,460	11,164	10,868
	14	2.5	11,300	11,004	10,708
	15	2.5	11,140	10,844	10,548
	16	2.5	10,980	10,684	10,388
	17	2.5	10,820	10,524	10,228
	18	2.5	10,660	10,364	10,068
	19	2.5	10,500	10,204	9,908
	20	2.5	10,341	10,045	9,749
Unit coal—14,900					
Coal No. 5 in Gallatin and Saline counties. Coal No. 6 in Moultrie County.	10	3.5	12,003	11,705	11,406
	11	3.5	11,842	11,544	11,246
	12	3.5	11,683	11,383	11,085
	13	3.5	11,522	11,222	10,924
	14	3.5	11,361	11,060	10,764
	15	3.5	11,200	10,898	10,604
	16	3.5	11,038	10,739	10,444
	17	3.5	10,877	10,578	10,284
	18	3.5	10,716	10,417	10,124
	19	3.5	10,555	10,256	9,964
	20	3.5	10,394	10,095	9,798
Unit coal—15,000					
Coals No. 5 and No. 6 in Gallatin County.			4% moisture	6% moisture	8% moisture
	10	4	12,650	12,350	12,050
	11	4	12,458	12,188	11,888
	12	4	12,326	12,026	11,726
	13	4	12,164	11,864	11,564
	14	4	12,002	11,702	11,402
	15	4	11,840	11,540	11,240
	16	4	11,678	11,378	11,078
	17	4	11,516	11,216	10,918
	18	4	11,354	11,054	10,756
	19	4	11,192	10,892	10,594
	20	4	11,030	10,730	10,430

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